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Electrical

SUPPLEMENT TO "THE ELECTRICAL ENGINEER," DEC. 26, 1890.

THE

ELECTRICAL ENGINEER.

A WEEKLY JOURNAL OF ELECTRICAL ENGINEERING,

WITH WHICH IS INCORPORATED

"ELECTRIC LIGHT."

VOLUME VI. (NEW SERIES.)

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1890.

INDEX TO VOL. VI. (New Series.)

NOTE.—General Articles, Correspondence, and Companies' Meetings are indicated by heavier type (thus, 290) than the Notes, references to which are shown by light type (thus, 290). It is hoped that this distinction between the numerals will save our readers the trouble of hunting through a long string of references to notes, when perhaps they are looking for articles or letters on particular subjects.

A.

B.

light linemen and for dynamo winders and other workmen using soldering materials.

Telephonic Switching.—An excellent paper, excellently illustrated, upon "Telephonic Switching," by Charles Henry Wordingham, A.K.C., Stud.Inst.C.E., has been issued by the Institution of Civil Engineers. The paper was read and discussed at the meeting of students on the 7th of March, 1890, and was awarded a Miller prize for the session 1889-90.

Gas-Electrics.—We fancy readers in England have little idea of how many gas companies in America work electric light also. From the list of stations in "Whipple's Reports" it appears that 276 gas companies in the United States also supply electric light; in Canada there are 21 gas companies with electric light plants; and in Mexico there is one company. This is out of a total of 970 gas companies in the States and 49 in Canada. Mexico has only one company, and that a gas-electric.

Fluoride of Aluminium.—In the French Academy of Sciences M. Minet describes a process of extraction of aluminium by the electrolysis of a fluoride of this metal in a molten state; he employs an electrolytic bath composed of chloride of sodium 60 grammes, double fluoride of aluminium and sodium 40 grammes. He gives various details of the method of procedure. He produces by this method 21·5 grammes of aluminium for an expenditure of 1 h.p. hour, and 30 grammes might be attained in actual practice.

Electrical Process for Pulp.—Pulp manufacturers are deeply interested in an electrical method of reducing wood in the manufacture of pulp. By this process it is claimed that the fibre is manufactured so cheaply that the entire pulp business will be revolutionised, and the digesters now in use be driven out. Kelner, of Germany, has been experimenting for several years with electricity in this direction, and has now succeeded in perfecting the process. A patent has been applied for in the United States.

Electricity Direct from Work.—The accomplishment of an hitherto apparently impossible feat—the useful transformation of mechanical work directly into electricity—is claimed by Prof. Braun, of Tubingen. He winds nickel wire into spirals, and as each spiral is elongated or compressed a current of considerable strength is generated. This is increased by putting a number of spirals in parallel. Such positive results are stated to have been attained that the professor is hopeful of being able to construct a practical generator on this principle.

Gatti's.—The central station established in the Strand by Messrs. Gatti's, the well-known restaurant proprietors, is reaching large proportions. Erected at first to supply their own wants at the Adelaide Gallery Restaurant, other persons near besought to be supplied, and extra machinery was put down. This was afterwards extended, and mains laid in the Strand. The central station—as it now has become—is being again extended, and sufficient plant to supply 25,000 16-c.p. lights will be shortly available. The machinery is being erected for Messrs. Mather and Platt by Mr. Spencer Chadwick, assisted by Mr. Earle. Room is yet obtainable to double this output if, as seems probable, the requirements rise to the amount of 50,000 lamps at a future period.

Meeting at Edinburgh.—With reference to the circular about arrangements for the Edinburgh meeting on July 15-17, issued to members of the Institution, we understand that both the London and North-Western and the Midland Railway Companies have consented to issue to any of the members return tickets of any class, available for eight days, at the same reduced price as already agreed to by the Great Northern Company—viz., a single fare and a quarter. The tickets will be issued from any of the stations on these lines on production of a note signed by the secretary which he will issue in a few days to all who may have intimated their intention to attend the meeting. These already number over one hundred. A circular accompanied by a programme of the proceedings will be issued.

Southend Electric Railway.—A meeting was held on the 21st ult. for the purpose of sealing the contract with Messrs. Crompton for the construction of the electric works for tramway and lighting on the new pier. The clerk read the contract, which specified that the temporary work was to be completed by August 1, and to be part of the permanent work, which is to be finished by May 1, 1891. In default of either, the contractors are to be under a penalty of £10 a day. Some discussion arose on the clause "if not prevented by any just cause," but this was sanctioned. The Board are to provide foundations and engine-house. The payments to be made are £2,880 (this year), £1,000, and £505. The surveyor has been instructed to proceed with the engine-house as soon as the plans arrive.

Smoke in Paris.—A severe attack has recently been made by the Paris Municipal Council on the electric light stations of Paris, including the Municipality's own station at the Halles Centrales. Thick smoke, noise, and shaking make the life of the neighbours a burden. Coke is not burnt, but "horrible coal." Paris has a law regulating factories, and the Council has decided that electric stations, not mentioned by the framers, are included. The engineers must therefore subdue and annihilate their smoke, and not make the air of the most brilliant city of the world comparable to the smokiness of our own London. When will the County Council of London frame a few stringent rules of the same tendency—not to diminish commercial activity, but to ensure clearness of atmosphere to the dwellers in the metropolis?

Austria.—The public electric lighting, which was inaugurated in Trient at the beginning of June, according to a correspondent, recently suffered an alarming accident. At 11.30 on the evening of the 27th ult. all the lights went out of a sudden, and as the moon was not shining the town was plunged in darkness. The day had been kept as a public holiday in honour of some local festival, and the streets happened to be full of people escorting some bands of music to the railway station, so that a great deal of confusion ensued. Fortunately the performance which had been held at the Opera in the evening was over, or the results might have been serious. The street lamps were relighted after an hour's interval. As the authorities have reason to believe that the extinction of the lights was due to an act of malevolence, a judicial enquiry into the affair has been ordered.

Electric Block Semaphores.—Various means have been attempted to place a visible record of the state of the section of a railway, whether blocked or not, before the train men as well as the station master. Perhaps the most successful of these, says the *Indian Engineer*, has been one invented by the telegraph superintendent of an Indian railway, a well-known electrician, and which has been adopted on some Indian lines, and still more extensively in Australia. This consists of a semaphore signal placed beyond the platform and electrically connected with the block instruments

in such a way that it can only be lowered from "danger" after the necessary signals have been interchanged between the ends of the section. The engine passing by the signal itself automatically sets it again at danger, and it cannot again be taken off until the arrival of the train at the other end has been signalled and the section again blocked.

New Storage Battery.—Messrs. Shippey Brothers, Limited, have on view and are introducing an entirely new type of storage battery, called the "Standard"; it is specially constructed for traction purposes and boat propulsion. The elements are light in weight, and are easily handled; the plate consists of a compound alloy, and instead of being vertical as is usual, they are made horizontal, and in multiple layers, separated by china discs. At present only one size and type will be made—viz., 17 plate cells, 200 ampere-hour capacity, size 6½ by 6 by 11 inches, adapted for rapid discharge. The inventors do not limit the rate of charge between 10 to 100 amperes, or even the discharge, provided the cell does not fall below 1·7 volts; buckling and warping is absolutely guarded against; and installations are to be kept in order under three or five years' contract, at a fixed and stated charge of 15 per cent. per annum.

Scientific Treatment of Boiler Water.—What seems to be an excellent idea from the point of view of employment of scientific methods to enhance the economy of steam boilers, is that carried out by Messrs. Sidney Minns and Co., Trafalgar-road, Dalston, who have introduced a system of analysis and diagnosis of impure water used in steam boilers, and the prescription of remedies arranged to cure any kind of impurity. The nature and amount of incrustation or corrosion varies according to the source of the water, and to use a boiler fluid haphazard does not always remove the difficulty. For every impurity a remedy may be found, and for this purpose an analytical chemist performs a special analysis on a sample of the water in ordinary use, and the boiler fluid is made up accordingly. Messrs. Minns have issued a neatly printed pamphlet giving particulars of their system, containing samples of various analyses of different kinds of scale in boilers, and fac-simile letters of testimony from a wide circle of users. We notice the names of the Metropolitan Supply, Mr. Ferranti, the Electric Construction Corporation, the Eastbourne and Chelsea Electric Light Companies, as users.

Manchester.—In the annual report of the Manchester Gas Committee, with reference to the electric light, the committee state that they have given careful attention to the questions relating to the supply of the electric light to a portion of the city. The area proposed to be supplied has been decided upon, the requisite clauses and provisions have been inserted in the draft provisional order and in due form have been laid before the authorities of the Board of Trade, and now await approval. The Board of Trade have already approved of the provisional order, and, judging from the decisions which have been given on the applications from Salford and other towns, it is thought to be pretty certain that the Board of Trade's approval will be confirmed by Parliament. In such an event the Gas Committee, who have the matter in hand, will probably advertise for tenders from the electric lighting companies for the carrying out of an installation or installations sufficient to meet the probable requirements of the area to which, in the first instance, the experiment will be confined. By the terms of the order the work must be carried out within a certain time, and if Parliament sanctions the order it is probable that the works for the supply of the electric light will be begun during the coming winter.

Mrs. Swan's Garden Party.—The garden party at the house of Mr. J. W. Swan, M.A., when Mrs. Swan received a numerous and brilliant assemblage of friends, took place on Wednesday afternoon. The long series of wet days and thunderstorm showers had rendered those concerned apprehensive of the proverbially fickle English weather, but fortunately the rain held off, and though an ominous growl was even heard once or twice, the afternoon was passed in a cool and pleasant atmosphere. Many persons distinguished in science, and especially electrical science, were present, and the costumes of the ladies made a lovely scene, and especially striking were those of the little programme distributers, who, in garments of pansy, poppy, and lily, tripped about distributing posies. One of the features of the gathering was the distribution of photogravures, printed by one of Mr. Swan's processes, taken of these children a day or two previously. Experiments in the electrical settlement of fog or smoke, after Dr. Oliver Lodge's method, were beautifully shown, the flakes of magnesium smoke appearing like a miniature snowstorm. Singing and sensitive flames also afforded much scientific interest and wonder. Mr. Grossmith gave some intensely humorous sketches in the drawing-room, and Mrs. Barker recited. The garden party reflected that atmosphere of mingled science and artistic culture which is such a distinguishing feature of Mr. Swan's home at Lauriston.

Glasgow Tramways.—The Tramways Committee of the Glasgow Corporation, who are the owners of the system, have during the last 12 months had the question of the renewal of the lease under their consideration. The attention of the leading members of the Corporation connected with the tramway undertaking—prominent among whom is Bailie Walter Paton, the convener of the committee—has been very much directed lately to the question of electricity as a motive power. From the enquiries they have made, and the experiments they have witnessed, those gentlemen are satisfied that electricity is the motor of the future, and that, moreover, it might have a very important place in solving the working of the Glasgow tramway system. Electric cars are already in operation in London, Birmingham, Liverpool, and other cities in England; and as the Corporation of Glasgow are promoting a provisional order for the purpose of securing the whole power of lighting the city with electricity, it seems to them obvious that if the Corporation can themselves supply the current which will be required for working the tramways, it can be done on a much more economical scale than by any outside company. It is equally obvious that it is not to the interest of the present tramway company, which has expended a considerable sum in providing stabling, horses, and cars, which are not adapted for being propelled by electricity, to adopt electricity as a motive power. In the meantime the Tramways Committee are securing all the available information on the subject, as it is necessary, within the next six months or so, to come to some decision.

Post Office Jubilee.—The *conversazione* of the jubilee celebration of the penny post was held on Wednesday evening in the South Kensington Museum, and a very numerous and brilliant concourse wandered about inspecting Post Office instruments—old type and new type—sending and receiving messages by line from Bristol or by cable from Berlin. Post offices in the old-fashioned style were fitted up, and the newest modern, and the expected future forms

of post office of 1990, with lightning express tubes, answers from all parts while you wait, indicated what we might expect in the next century. Perhaps the most interesting item of attraction was the "Electrophonoscope," a realisation of visual telegraphy, by which the sender of a telegraphic message could be seen as well as heard. The news of this was noised abroad a day or two before, in a cunningly-worded circular, and we know for a fact that not a few well-known electricians were anticipating the sight of a brilliant and memorable invention. It is said that the news was cabled to America, and it was even whispered that E-d-s-n had cabled back that he had already invented it and his credit must not be infringed. We give the text of the notice elsewhere. The affair was a huge joke of Prof. Hughes, F.R.S., such as this member ot the Royal *and* the Lion Club is known to delight in. An old artifice of the Prof. Pepper kind had been neatly rigged up so that the illuminated face of the speaker, some 30 yards away and round a corner or two, could be plainly seen nodding and gesticulating in a bright light—as the note says, "a realisation of what we may expect in 1990."

Llangollen.—At the last meeting of the Llangollen Local Board, Messrs. Fawcus and Cowan, the engineers of the electric light company, Keswick, having obtained permission to explain a project for supplying the electric light to Llangollen, appeared before the Board to explain the scheme, and reply to any questions relating thereto. A vast quantity of waterp ower, they stated, in the river at Llangollen was running waste, which could be utilised to supply the motive power for machinery to produce electric light for the public and private use of the town. The first question was whether that Board would be ready to entertain the question of lighting the streets with electricity. It would require but a very small space to lay down the plant. The machinery would be worked by a turbine as the cheapest and at the same time steadiest of all powers. At Keswick, in Cumberland, they had carried this system out, and it had proved a very great success. They considered that Llangollen was similarly situated to Keswick, in regard to the means of supplying the motive power. In reply to questions, it was further stated that, roughly speaking, the expense would be about £4 per lamp. A space of 28ft. by 18ft. would be sufficient to contain the machinery necessary to produce 1,000 lights. They were now negotiating for the lighting of hotels and houses at Llandudno. The total cost of the works for Llangollen would probably amount to about £5,000. The Board thanked Messrs. Fawcus and Cowan, who promised to send at an early date calculations which they thought would enable the Board to form a clearer idea of the matter.

Board of Trade Testing Station.—The Board of Trade having organised and largely increased their electric light department, some time ago took further offices at 8, Richmond-terrace, Whitehall, and Mr. Rennie, late assistant to Sir William Thomson, at Glasgow, is now busy fitting up the premises as a permanent testing laboratory. A 4 h.p. nominal Otto gas-engine is already down, belted to a Kapp continuous-current dynamo of 130 volts and 30 amperes, made by Messrs. Johnson and Phillips. The gas-engine is fitted with Crossley's new arrangement, doing away with the slide-valve. This consists of a closed gas-tube, heated to a dull heat from the outside, the lighted gas being drawn in without being allowed to communicate with the outer air. A further Kapp dynamo of 200 amperes is also to be put down. A set of accumulators of the ordinary type will be charged by these dynamos, and will drive motors which will run other dynamos, giving both high-tension direct and high-tension alternating currents. A few very large Crompton storage cells will also be fitted, charged by the 200-ampere low-tension dynamo. These will be used for calibrating and testing the instruments up to 2,500 amperes. A complete set of Thomson current balances will be fitted, and arrangements are now being made for the fitting of a large set of standard cells, and a static voltmeter is already in place, measuring 100 volts and thereabouts, built up as a series of quadrant voltmeters, and so indicating the potential with no passage of current. Other instruments are also being fitted, and this laboratory will doubtless form one of the most complete, as it certainly will be the most convenient in the metropolis.

Hong Kong.—The electric lighting of the main streets of Hong Kong will in all probability be completed by October. Most of the plant is already in the works at Wanchai, and operations are being pushed on. The electric light company have already been promised by the Government a contract for 50 arc lights on the Brockie-Pell system in the main thoroughfares. They will be placed along Queen's-road and the Praya at intervals of 150 yards. The present gas-lamps do not really illuminate the streets, but are only so many dim lights showing where the road is. The new lamps will also be used for concert-rooms and public halls as well. For house lighting it has been decided to adopt the alternating transformer incandescent system, now so extensively used in England. The lamps are 16 c.p. and 8 c.p., the former for apartments and the latter for passages and reading desks. There are three Kapp alternating dynamos, each capable of supplying 850 lights. They will be driven by compound engines working up to 100 h.p. indicated. Only two of the dynamos will be in regular use, the third being kept as a stand-by in case of a breakdown. These will, therefore, be nominally able to supply 1,700 16-candle lights, but really the resources will be much greater. Hong Kong is to be supplied with 3,500 8-c.p. lights. But it has been found from experience that there are seldom more than half the lights going at once, so that it would be possible to furnish 6,000 lights with the present plant. Every precaution has been taken against the stoppage of the light when once in use. The wires are extra-strongly insulated, and will be stretched between strong iron posts. There will be very little danger of their breaking, as they will be supported by strong steel "bearers."

Electrical Chemistry.—The erection of a factory for the manufacture of chlorate of potash by electricity at Vallorbes, in Switzerland, has already been announced. This process acts by decomposing the solution of chloride of potassium by the current according to the method of M.M. Gall and Montlaur. Mention has also been made of the manufacture of soda by electrolysis of sea salt. This process can be made commercial, it is found, if the power for the production of the current can be obtained from surplus power or from natural sources. The soap industry, which uses soda largely, is now, we hear, on the Continent attempting to employ this electric process for the production of soap, so that electric soap works may perhaps be those that will produce this now much advertised article in the near future. Electric bleaching of paper pulp is now commercially employed, and Darblay's large paper mill, of Essonnes, exhibited and worked a machine for this purpose at the Paris Exhibition. Lately Kellner, of Vienna, has de-

scribed the transformation of wood into paper pulp by the electrolysis of a salt solution into which the sawdust or wood was immersed. The disintegration and bleaching of the vegetable fibre took place at the same time by the action of the soda and chlorine formed by the passage of the current. We have seen that the electric tanning of leather greatly shortens the time necessary for manufacture. M. Perreur-Lloyd has shown that many commonly used chemical crystals can be well and more cheaply made than by ordinary systems and yet have a large current which can be usefully employed or stored, as a by-product. Electricity is gradually invading the whole domain of commercial chemistry, and few trades will remain that have not, in some form or other, an application of the electric current.

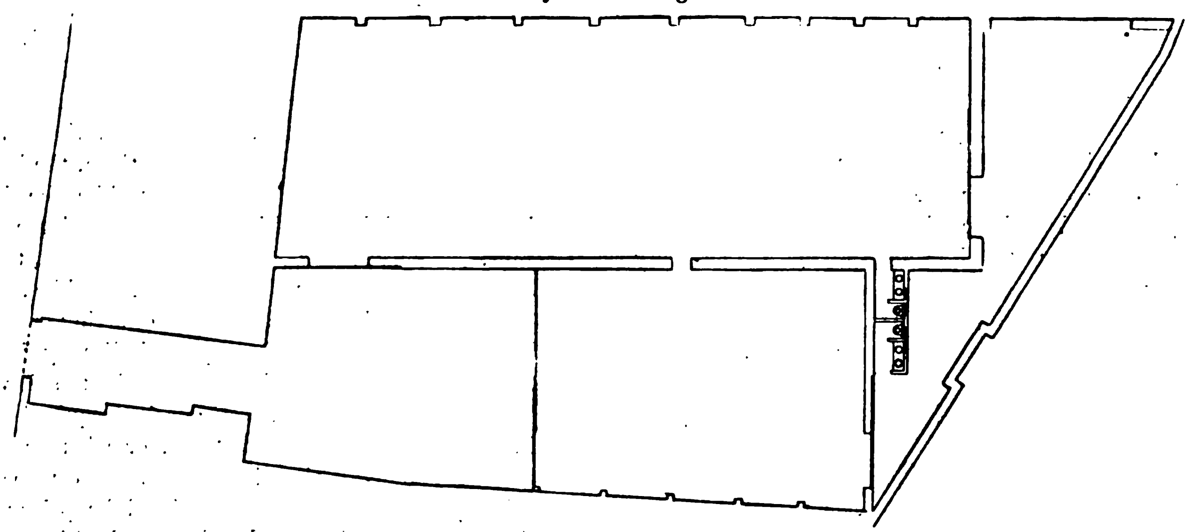
Madison-square Gardens.—What is claimed to be the largest enclosed place of amusement in the world was thrown open to the American public a fortnight ago, in the new Madison-square Garden, New York. There are four distinct features in this huge undertaking—an immense amphitheatre, a large theatre, a concert hall, and a café. There will also be an outdoor garden on the roof, and an observation tower. The steel trusses of the amphitheatre have 186ft. span. The building is lighted electrically, and has at present 3,600 incandescent lamps; the total number when completed will be 6,000 lamps. The plant consists of four Edison dynamos to start with to light the 3,600 lamps. These are driven by two 250 h.p. straight-line engines. Strung along on each steel truss, 60 odd feet above the floor, are 104 Edison incandescent lamps. A piece of moulding, carrying the tap wires, is clamped on the under side of the truss, and porcelain cut-outs with about 6in. of wire hanging from them suspend the lamps. Five large chandeliers hang from the ceiling. The centre one contains 600 lights, two others, one on each side of the centre, contain 300 lights each, and two more, one placed at each end where the trusses supporting the ends meet, contain 50 lights apiece. The greatest care has been taken in the arrangement. The wires are arranged for no more than 12 light fuses. The switchboard, when completed, will be a marvel in design. Any possible combination of lights may be effected, even down to lighting every alternate lamp in the building. The lamps are arranged so that a diffused effect is produced, there being practically no shadows. Wall brackets of neat and tasty design are used wherever required. On the columns supporting the trusses are large cluster lights. The work on the trusses was all run from above, no scaffolding being used. It will be the largest private installation for a single building yet carried out.

Magnetic Separator.—During the show week Mr. J. Harrison Carter, of 28, Mark-lane, E.C., has been exhibiting at the Royal Show, Plymouth, a magnetic separator designed to work in conjunction with his disintegrators. The separator is the joint production of Mr. Carter and Mr. Christy, of Messrs. Christy, Son, and Morris, Chelmsford. The object of the machine is to remove from the material fed into a disintegrator any bits of iron, such as bolts, horseshoes, etc., so as to avoid breaking the fans of the latter, a matter of frequent occurrence at present. When bones are required to be ground up the method employed is as follows: The bones are, by means of a shaking hopper, made to pass in a continuous stream over a cylindrical barrel studded with a number of powerful electromagnets set radially on a central core or yoke of cast iron, the outer ends being alternately north and south poles. The magnets are wound with insulated copper wire, through which an electric current passes—this current being controlled by means of the commutator at the end of the barrel in such a manner that all the magnets on the descending half are active, while the ascending ones are passive. As the material is shaken down the inclined hopper, the iron, being heavier, gravitates to the under side of the bones, and therefore falls directly on to the magnets and clings to them, the bones or other material falling off at the side, while the iron is carried round and deposited in a receptacle underneath the machine. This machine would usually be fixed on the floor above the disintegrator or other grinding machine, and in this way has the additional advantage of acting as an automatic feed, the material being spouted directly into the mill. Several modified designs are made to suit various purposes. The small amount of current required can be produced either by a small dynamo, or where a factory is electrically lighted the lighting current can be used. Mr. Christy also exhibits a portable hand lamp for millers, which has a strong wire guard and is fitted with a reflector, so that it is easy to examine the interior of a roller mill or other machinery by its means.

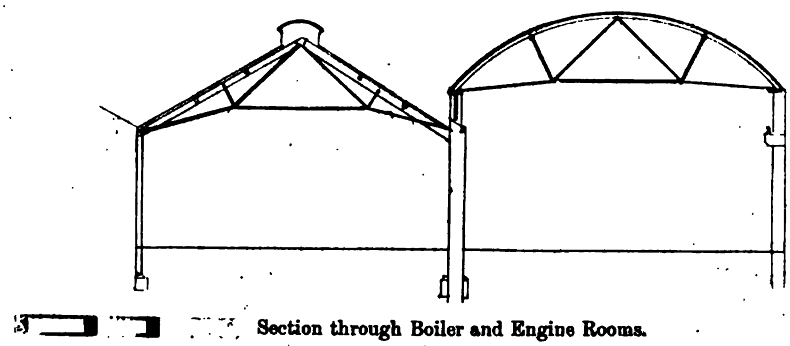
Okonite.—A large company for the manufacture of electric light and other cables has come out this week under the name of the International Okonite Company, Limited. The share capital is £340,000 in 17,000 preference and 17,000 ordinary shares of £10 each; 1,000 6 per cent. debenture shares of £10 each are also issued, repayable at par in 1910 as a first charge on the undertaking. The company is formed to purchase the successful business of the Okonite Company of New York, and to extend it to the United Kingdom and all parts of the world. For the purpose of extending the manufacture of okonite wires to this country, the wire and cable works of Messrs. Shaw and Connolly, of Newton Heath, Manchester, have been also acquired. The company have secured favourable reports from Sir Wm. Thomson and Dr John Hopkinson, who have consented to act as consulting engineers. The works in America, at Passaic, are new and extensive, with 400 h.p. water power available night and day at a charge of £7 per horse-power per annum. The progress of the company in America has been coextensive with the extension of electrical work, and from the reports shows increase in profits from £7,752 in 1887 to £10,558 in 1888, and £23,895 in 1889, and the sales for the first three months this year are nearly double those of last year, so that the estimated profits for 1890 are £41,237. The directors of Woodhouse and Rawson, who had the negotiations in hand, sent out their managing director, Mr. F. L. Rawson, who reported very favourably both on the business and on the commercial standing of the gentlemen connected with it. Messrs. Shaw and Connolly guarantee their books show last year's profits to be £4,000, whilst those for this year are at a rate of £6,000. The necessary additions and special plant for the manufacture of okonite cable at these works are already in hand. The remuneration of the American directors, of whom two agree to remain for at least two years, is 5 per cent. on the American profits. The foreign and colonial patents are included in the purchase. The purchase price fixed by the vendors, Woodhouse and Rawson United, who are the promoters, is £324,990, of which £113,330 is payable in preference and ordinary, and £33,300 in debentures, being the largest amount allowable by the rules of the Stock Exchange, and the balance in cash. The offices are at 34, Cannon-street, E.C.

BATH INSTALLATION.

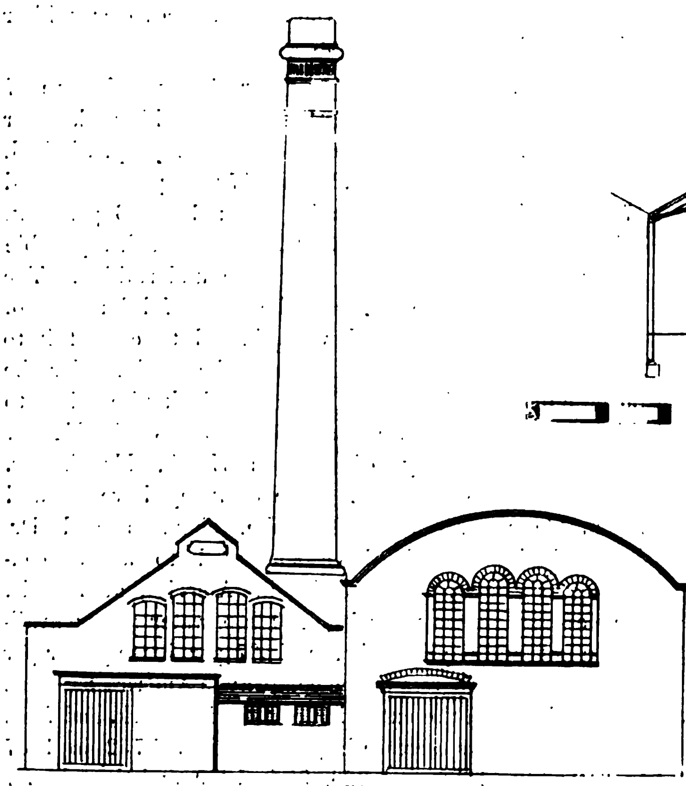
Stores. Dynamo and Engine Room.



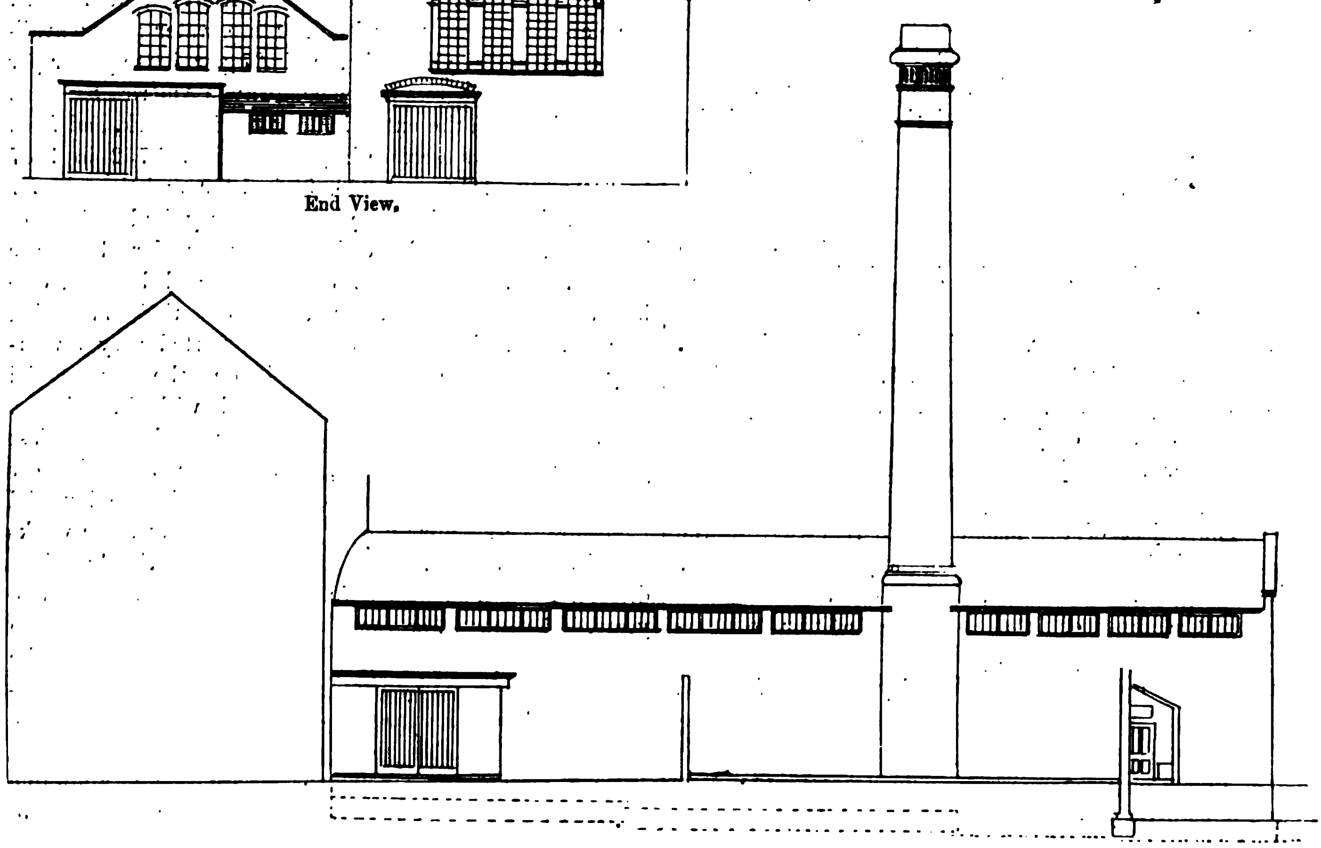
Yard. Boiler Room.



Section through Boiler and Engine Rooms.



End View.



Side View.

BATH INSTALLATION.

We herewith give some illustrations of this installation opened last week, and may recapitulate the apparatus used. lutions per minute. These are driving two Mordey Victoria 73-unit alternators to supply 3,000 10-c.p. lamps each. The alternators run at a speed of 500 revolutions per minute and are driven by rope belting One is an endless rope running through a guide pulley and round eight

Interior of Dynamo Room, from a photograph by Messrs. Vaisley and Collins

The engines were illustrated in our issue of April 25th. There are two Babcock and Wilcox tubular boilers each of 150 h.p. The engines are supplied by the Brush Electrical Engineering Company, and are six in number; of these two are 150 h.p. each and run at a speed of 200 revo- grooves on flywheel and alternative pulley. The other consists of eight separate ropes. The other four engines are each 35 h.p., and run at a speed of 230 revolutions per minute; these drive four Thomson-Houston 50 arc light dynamos, which run at 900 revolutions per minute. Mr.

A. M. Smythe is the resident engineer for the Brush Company.

The cables were manufactured and laid by Callender's Company, and are of two sizes—viz., 19/18 and 7/16. They are laid in iron troughs or cases, on bridges, and the whole space run in solid with bitumen. The amount of cable laid as mains is about 40 miles, this is through 55 streets. After running one of the circuits for three months the cable was tested and found to be over 30 megohms, or infinity on the instruments. There has not been one fault from beginning to end. All the circuits test over 30 megohms insulation resistance, and four of the circuits are between four and five miles in length. There have been put in 687 service-boxes, which will supply 1,374 houses. The amount of bitumen used amounts to about 130 tons. The arc lamps are supplied by the Thomson-Houston Company, and number 81 for street lighting. There are about 15 private arc lamps going at present, and we understand 15 more will be going shortly. There are about 3,000 incandescent lamps up at present.

THE EDINBURGH EXHIBITION.—IX.

At stand 86, Messrs. Gent and Co., of Leicester, show a large and varied assortment of electrical apparatus, including iron and brass frame bells, pendulum and drop indicators, Newmain's patent rotary indicator, watchman's clock, medical and other coils. At their stand may be seen Leonardts's water-level alarm for use with boilers, etc., to call attention to the fall in the level of the water. It consists of a magnetic float inside the water tube, and a brass box containing a swinging needle outside the tube. When the water is low and the float nears the bottom of the tube, the needle in the brass box is drawn towards the float and completes the electric bell circuit, causing the bell to ring until the water rises in the tube again. They also show a door fitted with an electric contact for ringing a burglar alarm bell. Miller's patent instantaneous fire detector alarm is also shown. This is an arrangement which is automatic in working and certain to work at the proper time. The new patent arrangement consists of wires connected at short intervals by joints of a fusible alloy which acts as fire detectors. These joints are so sensitive as to melt at from 150deg. F. to 200deg. as may be required. The jointed wires are carried in every direction, through all parts of a building, and connected with an electric battery. On the temperature rising to a dangerous point the joints at once melt, and their breaking brings about the movement of a switch which causes a stronger current of electricity at once to pass through, and instantly to set in motion any number of electric bells in as many places as may be needed. These bells are so arranged as to continue ringing till they are disconnected, and may be made to show the flat or part of a building in which the heat has risen to a dangerous point. By these means a most effectual alarm of the danger of a fire occurring, or of its having broken out, is at once given. There cannot possibly be any loss of time by this patent arrangement, as the fire itself is made to do duty as its own alarm, and to give an alarm while the fire is still in an incipient stage. The bells of these new patent fire alarms can be attached in any part of the house, or to the outside of buildings in streets, and alarm policemen, or even passers-by. The first cost, except a slight expense for keeping up the battery, is the only one in connection with it, as it will last for several years. The Universal electric telephones may also be seen here, and visitors will find a set of these instruments connected up and working through 150 yards of wire. These telephones have no permanent magnets or iron plates, nor is carbon or any other microphone employed. There are shown various medical and other coils, portable batteries, and street fire alarm apparatus, the working of which Messrs. Gent's representative is always pleased to explain to visitors.

The Fowler-Waring Cables Company, Limited, London, exhibit at stand 90 a very meritorious display of lead-covered cables for electric light, telephone, and telegraph purposes.

The stand consists of a trophy, 15ft. high, coiled with lead-covered cables of every description, exhibiting in this manner the ductility and pliability of the lead covering, together with cases containing sections of the various cables, in the centre of which are shown coils of some of the different sizes. Specimens of the method of jointing the cables are also displayed. It is stated that these cables may be joined easily and effectively to any other cables, and that there is no difficulty either in making joints to old cables or in continuing the length of the new ones. There appears to be practically no limit to the making of any length of these cables.

We understand that the cables manufactured under the company's patents have been and are extensively used all over America, and that they are at work in all parts of the United Kingdom and in France for every description of underground electrical work—mines, telegraphs, telephones, electric light, transmission of power, etc. They have also been introduced largely on board ships.

The dielectric of these cables has very high insulation resistance combined with great mechanical strength, and may be used for high electrical pressures. They are specially adapted for varying temperatures, being unaffected by extremes of either heat or cold.

The capacity of the telegraph cables is lower than that of guttapercha-covered cables—a fact of great importance, as it enables greater speed than was before possible to be worked on underground lines. On the stand are also shown specimens of joint-boxes, conduits, etc., and these, while being efficient, are simple and inexpensive, thus reducing the cost of laying to a reasonable figure.

The Magnolia Anti-Friction Metal Company of Great Britain, at stand 12, show a special anti-friction metal for bearings of dynamos and other high-speed machinery, also used largely in marine engines, locomotives, rolling-mills, etc.

They exhibit the following interesting tests—viz.:

1. The original bearing handed to them by the United States Government after having tested magnolia metal against Parson's white brass, proving their metal far superior; both durability and coefficient tests of friction are shown.

2. They exhibit a bearing taken from the crankpin of the steamship "Richard Anning," which has had a remarkable experience. During very heavy weather in the Mediterranean it was noticed that their bearing was a little hot and that it had to be kept cool by pouring water on it. This went on for 62 hours, the engines running at full speed. At the end of that time the ship got into smooth water, and on examination it was found that water coming into the engine-room had loosened the oil cup and so prevented their bearing from getting any oil for 62 hours. The consulting engineer states that if it had been any other metal than magnolia his opinion is that chances are 100 to 1 it would have melted out. The bearing shows a faultless bearing surface.

3. They then show magnolia tested against Parson's white brass by the Erie Basin Dry Dock Company in cone-shaped blocks. While magnolia metal remained perfectly intact under a pressure of 1,000lb. on the square inch, and at a speed of 2,000 revolutions per minute, Parson's white brass is shown to have fused at 604lb. pressure on the square inch and 2,000 revolutions per minute.

4. Then they exhibit a couple of railway brasses taken from the same axle, one lined with best babbit metal and the other with magnolia metal. These bearings had precisely the same treatment for nine months, at the end of which time they were taken out, and the magnolia metal shows only a fair bearing surface, while babbit metal is entirely worn away and running on the brass, and looks altogether in a cut-up condition.

5. The next test is a high-speed one, best babbit metal tested against magnolia metal: two little bearings run on the same journal at a speed of 4,000 revolutions to a minute, pressure 196lb. to square inch, tested to destruction. Both bearings have had the same treatment, and the babbit metal is shown to be entirely fused and melted, while magnolia shows a perfect and brilliant wearing surface.

6. They then illustrate the usefulness of magnolia in relining worn-out brasses, and exhibit a bearing taken from

the crankpin of ss. "Fidele Primavesi," which is composed of brass and had been condemned as useless, but according to the testimony of the consulting engineer of that line of steamers this condemned brass was strengthened on the back with a thick wrought-iron plate, then lined in studs with magnolia metal.

The bearing, after 17 months' running, is shown with a perfect wearing surface, inasmuch as in many places the tool marks are not worn out of the metal, a most remarkable result, and one that cannot fail to interest any practical man.

These exhibits are arranged around the base of a large pyramid, so constructed as to look like a solid block of magnolia metal. Altogether it presents an imposing appearance, and one very attractive to the eye.

HERING SECONDARY BATTERY.

It has been the constant effort of inventors to devise a form of secondary battery in which there should be a

Hering Secondary Battery.

maximum amount of active material so placed as to be secure from the buckling that so rapidly causes the destruction of many of the varieties of plates now in use. The latest effort towards this end, says the *Electrical World*, is a very ingenious one, devised by Mr. Carl Hering, well known to the fraternity as an expert electrician. The figure shows a vertical section of his battery, the simple type being exhibited, in which there are but two positive and two negative plates. The two outer plates are solid blocks of lead peroxide, such as may be made by mixing lead oxide in a solution of salts of lead, pressing the mixture in a mould and forming it into the shape desired. The two inner blocks are of spongy lead. Thus far there appears to be nothing especially unusual, peroxide of lead and lead being the elements ordinarily employed in secondary batteries. Now, however, comes the ingenious part of the invention. These blocks of lead and peroxide are not fastened permanently to any electrode; they are simply held in contact with the contact plates of lead or lead alloy, which lie against the flat sides of the blocks of active material, and project as shown through the top of the cell. The means taken to secure proper contact are simple. Perforated straps of non-conducting material pass, as shown, over the exposed surfaces of both positive and negative plates, keeping the plates firmly in contact with the removable electrodes and at the same time keeping them apart from each other. It would appear that this form of cell would not be likely to buckle, and would be of reasonably light weight, although its internal resistance would probably be a little higher than in the ordinary forms. It is impossible to tell *a priori* just what service to expect of a given proposed form of secondary battery, but Mr. Hering's plan seems to possess some decided merits. It can readily be taken apart; a single plate can be removed, if injured, and another substituted with very little trouble; and, in addition, it may be noted that the active material is formed in a block by itself, with which contact is afterwards made, instead of being mechanically applied to an electrode as in most of the batteries now used.

ELECTRICITY DIRECT FROM HEAT.

The American *Hartford Courant*, a newspaper which, it is understood, has always been looked upon as an organ of veracity at all times, publishes the following particulars in a recent issue in regard to a new invention to which allusion has already been made:

"For fifty years electricians have been trying to discover a method of converting heat directly into electricity. Until recently no results of commercial value have been obtained. Such a method seems now to have been discovered or invented by a young man from Maine, H. B. Cox. If Mr. Cox's claims are just—and capitalists have confidence enough in them to have formed a company with a capital of 1,000,000dols.—the whole system of power and lighting will be revolutionised, and steam will be regarded as too expensive for ordinary uses. It is impossible to estimate in advance the immense value of Mr. Cox's invention, but it is certain that he expects almost incredible results from it, and that he has inspired with his confidence some of the shrewdest business men of Hartford and Boston.

"As has been said, a company has been organised and incorporated in Maine, where Mr. Cox was when some Hartford men met him. Since then the business has all been brought to Hartford, and all that has been done since has been done at the factory of the Pratt and Cady Company. The capital stock is 1,000,000dols., and none of it is now for sale. Francis A. Pratt, of the Pratt and Whitney Company, is the president; R. N. Pratt, of the Pratt and Cady Company, is vice-president; and Ernest Cady, of the same company, is the treasurer. E. Henry Hyde, of Hyde and Joslyn, is a stockholder, one of the directors, and legal adviser of the new company. All the patents asked for by Mr. Cox have been allowed, and will be issued shortly. Both foreign and domestic patents have been applied for.

"The apparatus used for converting the heat into electricity is so simple that the company does not dignify it by the name of machine. By Mr. Cox's method heat is changed to electricity as simply as water is changed to steam. His furnace is all that may be seen. From glowing coal comes the subtle current, without the aid of boiler, engine, or dynamo. A jet of gas can be made to run a dental machine, a sewing machine, and anything which requires no more power than these. No power has ever been discovered that is half so cheap as will be electricity obtained by this new process. This has been the dream—apparently impossible of realisation—of all electricians; and even the wizard of Menlo Park has almost despaired of its ever being brought about. Yet a young man only 28 years of age seems to have solved the puzzling problem.

"Before the company was formed, Mr. Cox had a furnace at home by which he ran many electric lights. This furnace was injured in being transferred to Hartford, and a new one of the same size has not yet been completed. Experiments and private exhibitions have been conducted here on a smaller scale, but in a short time the company intends to show to the world that with the power thus obtained anything that steam or electricity now does may be done. Several members of the company saw what could be done with the furnace of Mr. Cox before any attempt was made to remove it. The one now being built will be an improvement on the old one and the results from it are expected to be correspondingly better.

"Most of the stock of the company is owned in Hartford. Some of it is held in Boston. The whole affair has been kept secret until the company should be ready to make it public. Even now the officers of the company are unwilling to talk for publication, but gossip about the new invention has been so frequent in Hartford and elsewhere, that it seems proper to print a general statement. The officers of the company say that they will be ready for public exhibitions in a few weeks."

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TELEPHONY.

The Post Office Jubilee Conversazione, held at the South Kensington Museum on Wednesday evening, was interesting in more ways than one. Perhaps more people were "fetched" by the little circular emanating from the high lights of science than was expected. The promise of the circular was great, the performance was to many who took the promise *au sérieux* somewhat disappointing. The reader who is not in the know will appreciate the text of the circular, which was as follows:

"THE ELECTROPHONOSCOPE.—This remarkable instrument will be exhibited for the first time at the Post Office Jubilee Soiree at the South Kensington Museum next Wednesday. It is the joint invention of Prof. Hughes, F.R.S., Mr. Stroh, and the Post Office officials. It solves the question of visual telegraphy. The sender of a message from a distant station appears in person before his correspondent, and with a telephone it is possible not only to speak to him, but to see him, and to watch the expression of his features. It is a perfect complement to the telephone, and will illustrate what telegraphy is likely to be in 1990."

Are we not right in saying that such a circular was enough to bring the greater portion of the scientific world of London and the home counties to South Kensington, and especially so as rumour, with its busy tongue, had stated that the great American electrical wizard, yclept Edison, had been informed of the invention by telegraph, and had replied that he had done it all before on his side of the Atlantic, and whatever had been done on this side of the Atlantic must necessarily be second-hand, and no doubt an infringement of his work. Well, the visitors came to South Kensington, they saw the wonderful invention, and they went away satisfied—satisfied at any rate that the problem of sending visual pictures by the electrical method had still further to be worked at before a solution was obtained.

The solution at South Kensington was simple, but it was not electrical; and though it served its purpose in attracting a large company, we do not expect to see it introduced into telephone exchanges. Looking forward is better than looking backward, and men must wait for the papers at the scientific societies or the year 1990, or put the invention aside for the moment as partaking of the character of a practical joke, before the details of the invention can be made common property. Hence, putting this special development aside for the time being, though its consideration leads us to think of telephony, it may not be out of place to glance at the present position of the industry. Elsewhere we give a description of recent extensions in Scotland; recently we gave similar information about the extension in the south-west. These will serve as a text to show what is doing—viz., the erection of trunk lines joining various business centres. Happy

is the man who wants the telephone and who lives outside the metropolis. In the greatest city of the world telephony is at its worst, yet the companies who are centralised here have undoubtedly to be credited with much of the good work that has been done elsewhere, and more and better work has been done recently in London than was possible in the days of the old *régime*. London is probably a big enough world of itself, though a little has been done in connection with trunk lines to other places—for example, Brighton, and negotiations have been made in other directions.

According to Mr. Bennett's statistics, the cost of a phonogram, or single telephonic message, is less than one penny, and probably the phonogram is more satisfactory to the sender than the telegram, which at the minimum costs sixpence. We take it that the labour of the office connected with the phonogram is equivalent to that connected with the telegram. Certain and satisfactory a phonogram ought to be, and if it be so, the extension of telephony means the extinction of a certain amount of telegraphy. The Post Office telegraphs may increase in number, and the income derived from them may also increase, but were there no telephones the income would be much greater. The problem, therefore, before the Postmaster-General is this: A loss occurs because of the development of telephony. On the other hand, a revenue is derived by telephonic royalties paid to the Post Office by the telephone companies. First, is the revenue equal to, less, or greater than the loss? Secondly, would the revenue be increased if the Post Office had all telephonic matters in its own hands? If an outsider listens to the telephone companies, he is told that the Post Office officials are incapable of properly working a telephone system; that hitherto most of the work they have attempted in this direction has ended in failure; that in places where both Post Office and a company has competed for business the latter has run right away from the Post Office, both as regards income and number of subscribers. On the other hand, the Post Office officials maintain that they and they only have the best exchanges; that their work is better, and more certain in action; that they have fewer complaints and fewer troubles; that in no case has there been real competition between officialdom and companydom, hence no argument can be founded on success or failure in such competition. Attempts have been made in the House of Commons to draw the Postmaster-General on the subject, but unsuccessfully. If, however, the cost of the two systems is as stated, and there is no reason to doubt the accuracy of the figures, the time is rapidly coming when telephonic extension must largely take place, when the ridiculous terms extant in London must be altered, and as good a service given there as in other places. In the country the extension of trunk lines brings whole districts together—Cardiff can talk with Bristol, Edinburgh with Glasgow; and under such circumstances telegraphy promises to become a thing of yesterday. Whether the possibility of putting speakers at the ends of telephone lines in sight of each other will ever be realised, is a subject of comparatively little importance practically. No doubt it is good to see with whom you are speaking, but the speaking itself is the great thing. Ordinary telephony gives that power, hence the great desire to see it increase and multiply continuously.

ELECTROLYSIS OF ANTIMONY SALTS.

BY ALEXANDER WATT.

In reviewing what may be termed the electrolytic history of antimony, it would appear that, with few exceptions, most of the investigations relating to the electrolysis of salts of antimony have been pursued more with a view to obtain interesting results than to discover which of its various salts would be most serviceable for preparing solution baths for the deposition of the metal for practical purposes in the arts. With this impression, I determined to undertake a series of experiments with the direct object of ascertaining the behaviour, under electrolysis, of numerous antimony salts with and without the admixture of other substances, my special aim being to find out which of the salts of antimony besides those usually recommended could be advantageously rendered available for antimony-plating. In my later work on electro-deposition* several solutions are described from which the metal may be deposited, but since some of these solutions present the disadvantage of being used in a somewhat high degree of concentration, I was desirous, in the course of my recent trials, to obtain electrolytes of a more moderate strength than those referred to, so that the deposition of antimony might be rendered more economical so far as regards the cost of the bath.

In pursuing the experiments which I have now the pleasure to describe, I soon found that solutions of high density were by no means necessary to the successful deposition of this metal; on the contrary, some very satisfactory results were obtained with solutions in an exceedingly dilute condition. This being the case, endeavours were made to obtain good working solutions containing moderate proportions of the metal, rather than adopting an extreme in either direction. The current employed in the various trials was derived from one or more Daniell cells, according to the nature of the electrolyte, and in some instances satisfactory results were obtained with the current from a single cell. Since antimony is very readily deposited from a great number of its solutions with the current from two cells of the battery referred to, any solution offering a higher resistance than would be overcome by the E.M.F. of three cells in series was put aside as of no practical interest. The cathodes employed consisted of a number of strips of sheet brass, 3in. by 1in., with copper wire attached by soldering, and the anodes were cast plates of antimony of similar dimensions. Under these conditions several trials were kept in progress at one and the same time, and the results duly noted when necessary.

1. *Tartrate of Antimony by Electrolysis.*—A solution of tartaric acid was first prepared by dissolving 300 grains of the acid in 10 ounces of water. In this solution was placed an antimony anode and a brass cathode, connected to three Daniell cells arranged in series. The electrodes were arranged at about an inch apart, and in rather less than one minute the brass plate was found to be coated with a slight film of antimony, indicating that the solvent action of the acid upon the antimony, under the influence of the current, was exceedingly brisk. The negative electrode was now

* "Electro-Deposition." By Alexander Watt. Third edition, 1889, p. 355.

placed in a small porous cell, charged with a solution of tartaric acid, and the action kept up, with the same current, for about an hour, at the end of which time the porous cell was removed, two of the cells disconnected, and a freshly-cleaned brass plate immersed, which at once became coated with a white film of the metal, the current from a single cell proving quite strong enough for a prompt deposit, while even with this weak current minute bubbles of hydrogen were evolved at the cathode. During the deposition the anode kept perfectly clean, and after a few hours' action the immersed surface exhibited unmistakable evidence of having been freely dissolved by the vegetable acid.

2. *Tartrates of Antimony and Ammonia.*—The foregoing solution was neutralised by cautiously adding ammonia, a drop at a time, under which altered condition it was tried with the same current as before, when a newly-prepared brass plate quickly received a coating of antimony of a good white colour. After a short time, however, the deposit began to blacken from the metal assuming a powdery, non-reguline form, to rectify which it was found necessary to further dilute the liquid by gradual additions of water. A fresh plate was tried after each addition of the water, but it was not until the solution had been diluted to the extent of about one-third of its original volume that the deposits afterwards obtained ceased to exhibit the powdery form of the metal.

3. *Potassio-Tartrate of Antimony by Electrolysis.*—A saturated solution of bi-tartrate of potassa (cream of tartar) was first prepared by digesting 300 grains of the salt in 10 ounces of hot water, the mixture being frequently stirred for a few minutes. After allowing the undissolved salt to subside, the clear liquor was decanted and used as an electrolyte, with the current from three Daniells, the electrodes being a cast plate of antimony and a brass plate for the cathode. In a few minutes after the plates were immersed, a streaky film of antimony formed upon the brass plate. The bath was then strengthened by immersing a small porous cell nearly filled with a solution of the bi-tartrate, a strip of brass being inserted as the cathode, and the electrolytic action was kept up for about 16 hours, by which time the liquid acquired a fair proportion of metal. The porous cell was then removed and a clean brass plate, connected to the negative terminal of two cells, immersed, which promptly received a deposit of antimony of a good white colour. It should be mentioned that the first deposit obtained from this solution, before it was strengthened in the manner referred to, was, as stated, streaky, and only appeared on portions of the plate facing the anode, while the back of the plate was uniformly coated with the metal. This peculiarity of deposition I had before noticed when experimenting with salts of cobalt, and it is a singular fact that it was also a solution of the potassio-tartrate of that metal which yielded a metallic deposit only at the back of the plate, while the front of the plate—facing the anode—received only a slight trace of the metal.*

4. *The Potassio-Tartrate Solution Neutralised with Ammonia.* The foregoing solution was next carefully neutralised with ammonia, and a freshly-cleaned brass plate immersed, the same current as before being used, when a bright film of a steel grey colour quickly formed, and after a long immersion of the plate it was found to be perfectly reguline, and quite free from the black pulverulent metal referred to in subsequent experiments.

5. *Tartrates of Antimony and Sodium.*—A bath was prepared by adding to a solution of tartrate of antimony prepared by electrolysis, as before, one of tartrate of soda. With the current from two cells, a very quick deposit of antimony of good colour was obtained, but after a short immersion of the cathode the metal deposited in the form of a black powder, which was readily wiped off the plate with the finger. The liquid was next diluted with water, in which condition it worked fairly well for a few minutes, when the black metal again made its appearance. The solution was again further diluted, and only a small surface of anode immersed, when the subsequent films of metal continued bright for a long time, but eventually assumed a somewhat dull light grey appearance, and, when dry, the deposited metal closely resembled electrolytic zinc, having a slightly bluish tint.

6. *Chlorides of Antimony and Ammonia.*—The formulæ sometimes recommended for preparing baths of this composition consist of "equal measures of a saturated solution of sal-ammoniac and commercial chloride of antimony," or, if prepared by the battery process, "two measures of a saturated solution of sal-ammoniac, two measures of hydrochloric acid, and one measure of water." Believing the above proportions to be unnecessarily extravagant, and to form an electrolyte of unnecessary density, I resolved to prepare a bath which would contain more moderate proportions of the metal and of the ammonia salt. With this end in view, I prepared a depositing solution of the following composition: saturated solution of chloride of ammonium one part; hydrochloric acid one part, and water three parts, all by measure. The bath thus formed was first tried with the current from two Daniell cells, when a brass cathode became coated with a brown film immediately after immersion, and this gradually became darker, until, in the course of a minute or so, the plate was coated with a dense layer of a deep black colour. The current from a single cell was next tried, with greatly reduced anode surface, under which conditions a fresh plate received a grey and somewhat dull deposit, but this was perfectly reguline and firmly adherent to the brass surface. A porous cell partly filled with the liquor was next put into the bath and a strip of copper inserted into the cell, and the current from two Daniells allowed to pass through the liquid for about 16 hours. The bath, thus strengthened, was now tried with the current from one cell, and very small anode surface—about one-eighth of that of the cathode—under which conditions a bright film of antimony at once "struck" upon the plate, and the deposited metal retained its brightness during a long immersion. It thus became evident that for all practical purposes the weaker solution (as compared with the formulæ referred to) could be advantageously worked as an antimony depositing bath. It is said of the strong solutions mentioned that they do not act so strongly upon base metals as chloride of antimony alone. I may say, however, that even the weaker solution which I have described freely coats brass and steel by simple immersion, but not so readily copper, unless the solution be heated, when this metal instantly becomes coated with metallic antimony.

7. *Terchloride of Antimony and Tartaric Acid.*—To a weak solution of tartaric acid was added, a little at a time, a solution of terchloride of antimony, when a dense gelatinous or gummy precipitate formed, which readily dissolved in the tartaric solution, forming a straw-coloured liquid. This solution was next neutralised with ammonia, and then electrolysed with the current from a single Daniell cell, when a bright film of antimony soon formed upon a brass plate. After a time, however, black non-reguline metal deposited upon the plate, even when the immersed anode surface was much reduced. It was deemed advisable to still further dilute the solution, which greatly improved the character of the subsequent deposits. It was not, however, until the bath had been considerably weakened by additions of water that bright deposits could be obtained free from the black pulverulent form of the metal. When the dilutions had been carried far enough, however, the black metal ceased to appear and the films retained their brightness. I have generally found it to be the case, when electrolysing solutions of antimony salts, that the black form of the metal invariably appeared after a time under the following conditions: The current being too strong; the bath in a too acid condition; or if it be too rich in metal. The reverse conditions, therefore, would appear to be the most favourable for obtaining good reguline deposits of this metal.

8. *Citrate of Antimony by Electrolysis.*—A solution of citric acid was first prepared, in which was placed an antimony anode and a plate of brass for the cathode, the electrodes being connected to a three-cell Daniell battery. In a few minutes after immersion the brass plate received a coating of antimony nearly as white as electrolytic cobalt. Deposition was not so brisk as was the case with

**Electrical Engineer*, February 15, 1889, p. 131.

the tartrate solutions, but the colour of the metal was somewhat better and very bright.

9. *Oxychloride of Antimony in Citric Acid.*—To form a bath, recently precipitated oxychloride of antimony was digested in a nearly boiling solution of citric acid, in which it readily dissolved, forming a nearly colourless solution. After being moderately diluted with water, the solution was electrolysed with the current from two cells, when a very bright deposit of antimony of good colour was obtained upon a brass plate, to which the metal firmly adhered.

10. *Sulphate of Antimony by Electrolysis.*—A solution of sulphuric acid (about 1-10) was electrolysed with the current from three cells, the action being kept up for about 48 hours, with an antimony anode and a brass plate immersed in a portion of the solution contained in a porous cell as before. After a few hours' immersion of the electrodes, a slight deposit of antimony was found to have deposited on the brass plate, and at the end of the period before named the porous cell was removed, and a clean brass plate immersed, the current from two, three, and four cells being tried in succession, but the solution proved to be a very bad conductor, while the deposits obtained were not of a satisfactory character. The bath was therefore abandoned. A solution of bisulphate of potassa (sal enixum) was also tried in the same way as the above, but although a slight film of antimony appeared upon a brass plate when the solution was electrolysed with the current from three cells, the results were not satisfactory. An addition of sulphate of ammonia did not improve the condition of either of the foregoing solutions.

12. *Acetate and Sulphate of Antimony by Electrolysis.*—A solution of the mixed acids was prepared by adding to 10 ounces of water, five fluid drachms of sulphuric acid and two ounces of acetic acid. With the current from two cells, passing through an antimony anode immersed in the liquid, a brass cathode received a slight film only of metallic antimony after several hours' immersion.

13. *Protochloride of Antimony Precipitated by Carbonate of Soda.*—Instead of precipitating the oxychloride of antimony by water in the usual way, the writer's son, Mr. Newton Watt, employed a solution of carbonate of soda, and he found that the precipitate thus obtained was more freely soluble in various menstrua than the ordinary oxychloride. A quantity of the precipitate being thus prepared, was afterwards digested—in most cases with the assistance of heat—in solutions of various substances, the results of which will next be described.

14. *Oxychloride of Antimony in Oxalic Acid.*—A quantity of the moist precipitate obtained as above was digested in a hot solution of oxalic acid, in which it dissolved freely. With the current from three cells a deposit of metallic antimony of a dark colour formed on the brass cathode a few minutes after immersion. The solution was not a good conductor.

(To be continued.)

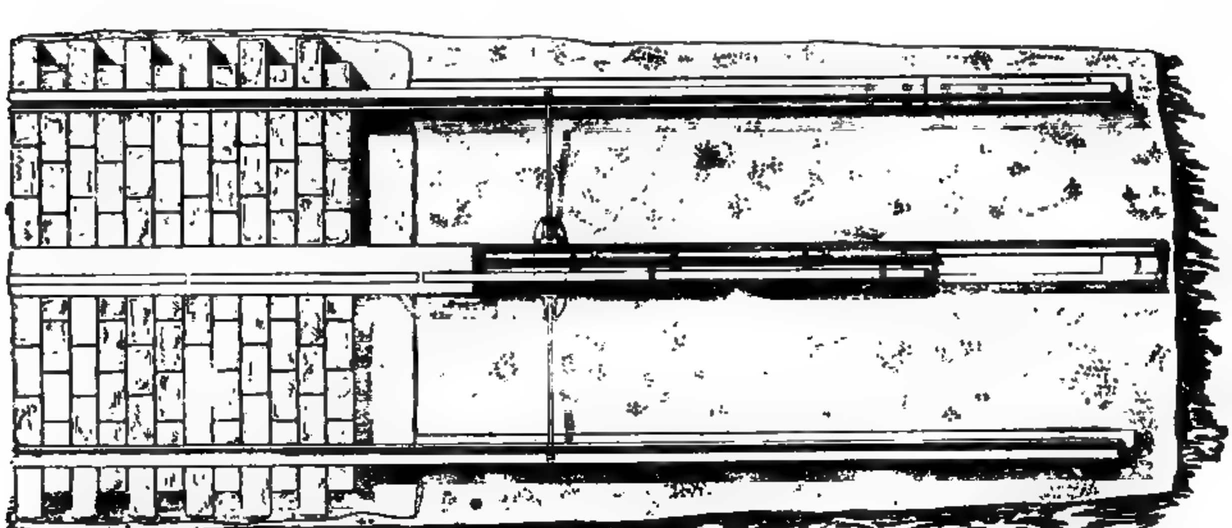
THE LINEFF MAGNETIC CONDUCTOR.

The new Lineff conductor for tramways is said to be the first which has successfully taken advantage of the force of

MAGNETIC CONDUCTOR FOR TRAMWAYS: LINEFF'S PATENT.

CENTRAL ARRANGEMENT.

SECTION OF TRACK: SCALE 3 INCHES TO ONE FOOT.



PLAN OF TRACK: SCALE 1½ INCHES TO ONE FOOT.

11. *Acetate of Antimony by Electrolysis.*—A quantity of commercial acetic acid was decomposed with the current from three cells, with an antimony anode and a brass plate being used as the cathode as before. The action was slow, but after an hour or so the brass plate received a slight film of antimony. A white deposit, however, formed upon the anode, which appeared to check the flow of the current, and the experiment was therefore discontinued.

magnetism, in closing the circuit in electric traction. The surface rails are laid in lengths of about 3ft. in a bed of asphalte, and as they are without any groove, and have their upper surface flush with the roadway, they cannot form any obstruction to traffic either along or across the track. In point of fact they are hardly to be distinguished from the roadway itself.

Each of these rails is bolted by means of brass bolts and

distance pieces to a piece of tee iron of equal length, so placed as to have its base on the same level as that of the surface rails, at a distance from it of about a quarter of an inch. The tee iron, being of lower height than the surface rail, does not appear at all on the roadway, being completely buried in the asphalte surrounding the whole. One end of the tee iron projects beyond the corresponding end of the surface rail, so that the rails when laid in position break joint with one another all along the road.

The two irons together form a roof to a continuous channel 3½in. wide, formed by insulating tiles on which the irons rest. This channel contains the bare copper main, shown in the drawing as a flat strip, and on this rests a flexible hoop iron 3in. wide, which is free to rise into contact with the lower flanges of the surface and tee rails, from which it is in its normal position distant about $\frac{5}{16}$in.

Each car carries underneath it an electromagnet, each pole of which contains a solid iron wheel which runs on the surface rail. The distance between the pole-pieces is slightly greater than the length of one section of the surface rail, so that the two poles are never on the same section.

The magnet is energised by the main current, the wire forming the coils being coupled in shunt with the motor circuit.

The magnetic lines emanating from the magnet poles pass into the surface rail. The section of this being insufficient to carry the whole of the magnetic lines, a large proportion of them leak across to the buried tee rails, and as the connection between each pair of rails (surface and buried) is of a non-magnetic material, the lines jump across the air space between the lower flanges. Opposite poles are consequently induced in each of the surface and tee rails under the immediate influence of the electromagnet, and the leakage "cross" lines being diverted through the strip of hoop iron lying immediately below the air gap, in their attempt to shorten themselves attract the hoop iron into contact with the bases of the surface and tee rails; both of which, as they are in electrical (though not in magnetic) connection, assist in taking off the current.

THE TELEPHONE IN SCOTLAND.

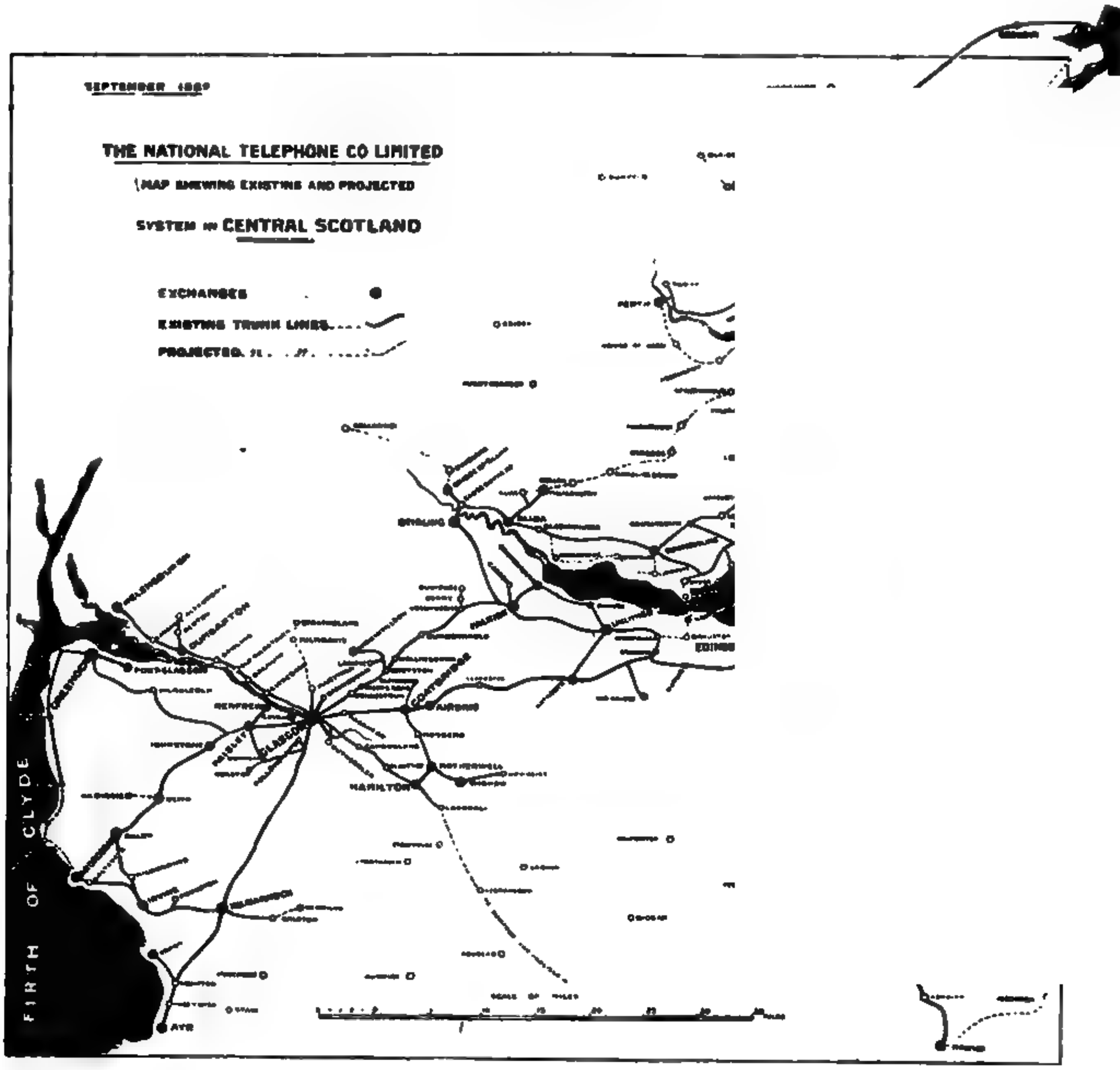
We give herewith a sketch map showing at a glance the chief part of the telephonic system of Scotland, including the new trunk lines. The National Telephone Company, Limited, represented by Mr. A. R. Bennett, may be said to own all the public lines in Scotland, and has certainly kept pace with the calls made upon it. At first the progress was somewhat slow, and the exchanges did not extend beyond the areas of the respective communities; but as the manifold advantages of the system began to be perceived the local barriers were soon overcome, and many of the chief towns are now linked together in a chain or chains of communication. First in point of interest is a new direct wire *viâ* Stirling and Fife, bringing Edinburgh and Dundee within easy speaking distance. The company already possessed lines between the two cities, but they were broken up into sections, and were not readily available for direct working. The wire is of copper instead of galvanised iron.

Notwithstanding that the Dundee line is 109 miles in length, the speaking is very distinct, proving that the insulation is very perfect, as with a wire of such length it must necessarily be. The company hope in the course of a short time to cut off a portion of the loop by getting permission to carry the wire over the Forth Bridge, thus greatly reducing the mileage, and bringing Fife into readier communication with the south. Fife, it may be said, was one of the first counties in Scotland to realise the benefits conferred by the telephone, which is of inestimable service in connection with its various industries. Of course, Edinburgh subscribers will now have the privilege of communicating with Dundee quite as readily as with their nearest subscribing neighbour, the charge being at the rate of 1s. per three minutes' clear conversation. Another important line just completed is that connecting Edinburgh with Galashiels, Selkirk, and Hawick, where again the working is admirably clear. The charge between Edinburgh and Galashiels or Selkirk will be 6d., and between Edinburgh and Hawick at 9d., for three minutes. Then the demands of the Glasgow business have necessitated the erection of two new lines, making four in all, with the advantage that beyond Broxburn, whither they are carried along the Union Canal, they are conveyed by a different route—namely, by Bathgate and Airdrie, thus lessening the chance of interruption by accident. Further new lines have just been opened between Edinburgh, Broxburn, and Bathgate, and between Cupar and St. Andrews, while Aberdeen, in the course of a few weeks, will be brought into communication with Dundee.

All this betokens great and encouraging progress, and it is satisfactory to know that the enterprise of the company is meeting with its due reward.

Mr. Bennett, in the course of some of the congratulatory speeches at the inauguration of these new lines, recalled the fact that the inventor of the first practical telephone, Mr. Graham Bell, was a native of Edinburgh, and mentioned some incidents in connection with his career which are not generally known. A cousin of Mr. Bell's, who was present, stated that Bell, when a mere youth, attempted to devise various means whereby his mother, whose hearing was defective, might not only be made to hear readily, but be communicated with from adjacent rooms. He was in the habit of having sounds transmitted along wires, noting their effect and duration, and he endeavoured to utilise them by various means. Owing to those experiments he was accounted rather foolish by his schoolmates. As the germ of his great idea was conceived out of his regard for his mother, so it ultimately came to be perfected by reason of his devotion to his wife. Bell became a teacher of the deaf and dumb in Boston, and married a lady partially afflicted. His increased knowledge of the structure of the ear led him in course of time on the right track, and although audible sounds had been transmitted by other experimenters, both in France and Germany, it is to Bell that the credit of the perfect telephone is undoubtedly due. When he visited Edinburgh some 10 years ago, to push his invention, his devotion to his wife is described by Mr. Theim as having been very touching. He had succeeded in enabling her to understand conversation and to be understood, and his attention to her was unceasing. His reception in the city of his nativity was not of a kind which will redound to his credit. He remained for a month or so, and Mr. Theim interested himself in the matter, seeking interviews with university professors and other scientific authorities, but one and all would have nothing to do with the "toy," and Bell had to turn his steps to London, where fortunately he met with greater success. It is a curious fact that he himself did not perceive all the great possibilities before the telephone, and did not encourage the idea of "exchanges," which have since developed all over the world.

Mr. Bennett stated that although Graham Bell was the first to produce an actual telephone, the possibilities of such an instrument had been floating in the minds of people for generations, perhaps ages past. There was a passage in Job. xxxviii. 35, "Canst thou send lightnings, that they may go and say, Here we are?" That question, no doubt a poser at the time, Bell had enabled us to answer in the affirmative. He had shown us how to send lightnings, in a small way, and, if so desired, to make them say, "Here we are," although telephone subscribers were more addicted to the phrases "Hello!" and "Are you there?" Another passage in Psalm xix. 4, "Their line is gone through all the earth, and their words to the end of the world," had also a telephonic flavour, and he hoped that the words might, at no very distant day, be applicable to the National Telephone Company, since the company did not intend to rest until every town and village were on speaking terms, and the telephone system became co-extensive, at least, with that of the telegraph. In replying to the toast of "Prosperity to the National Telephone Company," proposed by Mr. James Shepherd, Mr. Bennett gave the following particulars of revenue, calls, and trunk mileage of the telephone companies at 31st March, 1890, which are of importance at the present time.



—	No. of lines.		Revenue.			Calls or connections per annum.	Trunk mileage.		Per connection.
	Ex.	Pri.	£	s.	d.		M.	Y.	
National	22,316	4,910	387,172	9	11	46,800,000	9,831	576	1·98
Northern District	1,291	237	18,232	5	0	1,488,891	1,711	...	2·94
South of England	2,252	541	22,964	0	0	3,619,364	320	...	1·52
West'rn Counties	2,509	678	32,850	0	0	2,853,000	1,850	...	2·76
Telephone Co. of Ireland...	938	429	12,311	6	7	1,720,910	299	896	1·71
	29,306	6,795	473,530	1	6	56,482,165	14,011	1,472	2·01

No. of lines: exchange, 29,305; private, 6,795; total, 36,100. Revenue, £473,530. 1s. 6d. Calls per annum, 56,482,165. Trunks mileage, 14,011 miles, 1,472 yards.

As each connection implied a question and answer, and consequently was equal to two telegrams, the number of messages therefrom equalled very nearly 100,000,000. Dividing the revenue by the connections, it was found that the average cost to the subscribers was 1·98 of a penny, treating each connection as two messages, the average cost per message was only ·99 of a penny, a price which included messages over long trunk as well as short urban lines. The length of the company's trunk lines connecting the chief towns of England and Scotland was nearly 10,000 miles at the same date, and this was increasing daily.

THE IMPORTANCE OF ACCUMULATORS FOR THE ECONOMY OF CENTRAL STATIONS FOR ELECTRIC LIGHT.

BY DR. GUSTAV RASCH, AACHEN.

The recent progress made in the manufacture of accumulators is such that it cannot remain without great influence on the whole of electrical engineering, and especially on public electric lighting. The accumulator occupies a very distinct position amongst electrical apparatus: it is no source of E.M.F. if considered simply by itself; it does not make up for a want of machine power at disposal; it is not even an absolutely safe reserve for a longer space of time, but its use allows us to improve the efficiency of a plant, and therefore to reduce the cost of running.

The reason why accumulators have not up to the present entirely filled this prominent position is principally to be found in their high price and small durability, so that the enormous depreciation necessary to be allowed, added to the cost of running, completely balances the saving obtained by the more economical running of the machinery. There now appears a change for the better, especially as to the durability; some manufacturing firms now grant such guarantees that the consumer may safely reduce the percentage of depreciation, and it is to be hoped that with increasing use of accumulators their price also will be lowered.

The following data will show that already for the present state of the manufacture, accumulators have a large share in reducing the cost of running in an electric central

station, without taking into consideration the use of storage cells for regulating the tension at a great distance or for transforming a continuous current in sub-stations; we only regard here accumulators as part of a central station to accumulate electric energy, a very important feature, as the consumption varies very much according to hour and season, and as the economy of a dynamo alone is good only for an average normal load.

In order to properly understand the importance of accumulators for this purpose, let us first consider the variations which the efficiency of a continuous-current dynamo undergoes with different loads.

The mechanical energy which is introduced into the dynamo, measured in watts, consists of three different parts. 1, L, the work required for running the dynamo without load, including the energy for exciting the field-magnets; 2, the second part, $a \times W$, is proportional to the available energy, W, as measured at the terminals; 3, the third part is the energy which is converted into heat in the machine (as far as it depends upon the load) and which is proportional to the square of the external current, or, in this case, of a continuous-current dynamo, to the square of the output. The efficiency, w, of the dynamo may be written

$$w = \frac{W}{L + a\,W + b\,W^2}.$$

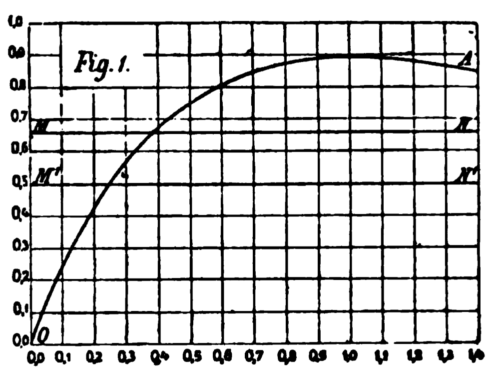
Let ξ be the ratio of the present output to the normal output and α, β and γ three constants, then

$$w = \frac{\xi}{\alpha + \beta\,\xi + \gamma\,\xi^2}.$$

A well-built dynamo has its best efficiency for a normal output ($\xi = 1$), and if w becomes a maximum, γ must be equal to α, so that

$$w = \frac{\xi}{\beta\,\xi + \alpha\,(1 + \xi^2)};$$

An efficiency of 88·5 per cent. for normal output, and 75 per cent. for half this output, already supposes a good dynamo, for which $\beta = {\cdot}331$ and $\alpha = {\cdot}401$.



This equation is plotted as the curve O A in Fig. 1; the abscissæ are ξ, and the ordinates the efficiencies w. Suppose, now, a storage battery with 75 per cent. efficiency be charged at the normal load of the machine, a condition easily to be realised; the actual efficiency of the battery in reference to the shaft of the dynamo is

88·5 × ·75 = 66·4 per cent. (line M N in Fig. 1).

In order to take into account the interest and depreciation of the battery plant it is advisable to reduce the above efficiency to, say, 50 per cent. (line M′ N′), which is far worse than it would be in actual running. The diagram shows that it is of advantage to use the accumulators if the load of the machines is less than one quarter of their normal output. In order to avoid the use of accumulators it would be necessary to erect a series of small dynamos instead of one or two large ones, so as to better conform the work to the variations of the consumption, but there are three great disadvantages connected with this latter method: the manipulation of the plant is less simple, the cost of putting down the plant is increased, and the total efficiency will be reduced. In neglecting these facts, and supposing that the available power (of course, sufficient for the highest consumption in December) be transmitted to six dynamos, we should still have about 11 hours a day (that is, 46 per cent. of the whole time of running) when a single one of these six dynamos would be working with less than one quarter of its normal output and when accumulators would be in their place. These data are taken from load diagrams of a central station for 12 months from the books of Dr. M. Krieg* and W. Fritsche†.

Further, it should be considered that the motors, too—no matter whether steam or gas engines—give their highest efficiency for normal load, and therefore it is desirable to run the motor plant with normal load for several hours a day, then to shut it down and to supply the consumers by accumulators, which were charged in the meantime.

There is, of course, for each central station a special economical size of the storage battery, which might be called the "economical capacity," just as there is for each electric main an economical section. If this be taken too small, the costs of coal, oil, and lubricating materials for the uneconomically loaded machines increase the cost of running; if taken too high, their interest and depreciation have the same increasing effect upon the working expenses. Consequently there must be a certain capacity of the accumulators between those extremities which reduces the annual cost to a minimum. We have not to consider those expenses to which the sort of motive power makes no difference, and only have to deal with—

1st. Interest and depreciation of the boilers, steam-engine or gas motor, and dynamos.

2nd. Interest and depreciation of the storage battery.

3rd. Interest and depreciation of the instruments and appliances for the control of the motive power.

4th. Cost for attendance and maintenance of the machinery and accumulator plant.

However, it is not so very easy to get the "economical capacity" of the accumulators into a mathematical formula, as it is possible for the economical section of a cable, for instance: we must take into account the load diagrams and the working expenses, as mentioned above, for different capacities. We shall hereafter show the best way in which to do this, but first we have to say a few words about the depreciation of the boilers and machinery.

Herr Fritsche generally assumes the depreciation as 5 per cent. for steam-engines and dynamos, and 10 per cent. for the boilers; but I think this is not quite correct, because a machine which has to do double the work will probably show double the amount of wear, and it therefore will be better to take the depreciation as a function of the relative load—that is, the horse-power hours given out in a certain space of time divided through those horse-power hours which would have been given out from the machines in the same time for the constant normal load.

If β stands for this ratio the depreciation will be: for boilers $(8 + 12\,\beta)$ per cent.; for steam-engines and dynamos $(4 + 8\,\beta)$ per cent., although it is of no great importance that this is the exact percentage for actual running; it is only necessary that we take our figures not too favourable.

With the supposition that the depreciation of running material is a function of the load, we are much more likely to put down a reserve plant, as the cost of running is only increased by the interest of the reserve, while the depreciation will remain just the same, because the plant is then less worn out.

The economical capacity of the accumulators is obtained in the following way: First, take from the diagrams of Dr. M. Krieg and W. Fritsche the curve for December and determine the arrangement of the motive power, so that in case of a failure at one machine the supply can be done by the other machines, together with the storage cells, without loading any part of the plant beyond the safe limits; then, by adding the ordinates of the 12 monthly curves, we get an average curve for the consumption throughout the whole year, which is the basis for the investigation of the working expenses. Next, we have to find by calculation and graphic construction:

1. Interest and depreciation, and repair of the boiler, steam-engine, and dynamo plant.

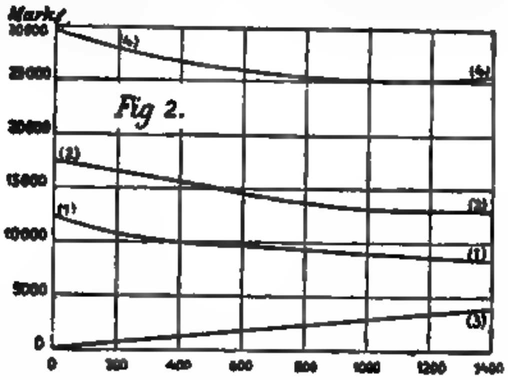
2. Costs of materials—viz., expenses for coal, water, oil, cleaning, and lubrication.

3. Interest, depreciation, and repair of the accumulator plant.

* Krieg, "Generating Electricity in Central Stations."

† Fritsche, "The Erecting, Maintaining, and Rentability of Electric Light Central Stations." *Centralblatt für Elektr.*, 1888, p. 423.

All these points must be determined for different capacities, and also for a plant without accumulators—that is, for the capacity zero. If we now plot these three values as



ordinates for different capacities as abscissæ, we get the curves shown in Fig. 2, which are lettered as the points above.

(To be continued.)

MAIN SWITCHES.

A new pattern of gunmetal main switch which is now being made in several sizes in both single and double-pole

Single-pole Switch.

type by Messrs. Dorman and Smith, of Manchester and London, is illustrated in the accompanying engravings.

Double-pole Switch.

These are good, strong switches, with a sudden and double break, and a good contact. They are on slate bases, and can be fitted for coupling up either at the front or the back.

ELECTRIC LIGHTING, SESSION 1890.

The following is a list of provisional orders granted by the Board of Trade, or still under consideration, with the title of order and description of area, name of promoters, and agents respectively:

Accrington Electric Lighting Order—Municipal Borough of Accrington; The Corporation; Messrs. Lewin, Gregory, and Anderson, 13, King-street, Whitehall, S.W.

*Aberdeen Electric Lighting Order—City and Royal Burgh of Aberdeen; The Corporation; Messrs. Martin and Leslie, 27, Abingdon-street, Westminster, S.W.

Ashton-under-Lyne Electric Light and Power Order—Municipal Borough of Ashton-under-Lyne; Municipal Electric Light and Power Corporation, Limited; Messrs. William Webb and Co., 6, Essex-street, Strand, W.C.

Ayr Burgh Electric Lighting Order—Municipal Burgh of Ayr; The Commissioners of Police; Messrs. Grahames, Currey, and Spens, 30, Great George-street, Westminster, S.W.

Bacup Electric Lighting Order—Municipal Borough of Bacup; The Corporation; Messrs. Lewin, Gregory, and Anderson, 13, King-street, Whitehall, S.W.

Barnsley Electric Lighting Order—Municipal Borough of Barnsley; The Corporation; Messrs. Durnford and Co., 38, Parliament-street, S.W.

Bedford Electric Lighting Order—Municipal Borough of Bedford; The Corporation; Messrs. Ullithorne, Currey, and Villiers, 1, Field-court, Gray's Inn, W.C.

Belfast Electric Lighting Order—City of Belfast; The Corporation; Messrs. Dyson and Co., 24, Parliament-street, S.W.

Birkenhead Electric Lighting Order—Borough of Birkenhead; The Corporation; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.

Blackburn Electric Lighting Order—Borough of Blackburn; The Corporation; Messrs. Tahourdins and Co., 20, Victoria-street, Westminster, S.W.

Blackpool Electric Lighting Order—Municipal Borough of Blackpool; The Corporation; Messrs. Dyson and Co., 24, Parliament-street, S.W.

Bognor Electric Lighting Order—Local Board District of Bognor; The Electric Trust, Limited; Messrs. Wyatt and Co., 28, Parliament-street, S.W.

Bournemouth Electric Lighting Order—The District under the control of the Bournemouth Improvement Commissioners, together with a portion of the District of the Poole Urban Sanitary Authority; Brush Electrical Engineering Co., Limited; Sydney Morse, Esq., 4, Fenchurch-avenue, E.C.

Bournemouth Electric Supply Order—Urban Sanitary District of Bournemouth; South of England House-to-House Electricity Co., Limited; Messrs. Wyatt and Co., 28, Parliament-street, S.W.

Burnley Electric Lighting Order—Municipal Borough of Burnley; The Corporation; Messrs. Tahourdins and Co., 20, Victoria-street, Westminster, S.W.

Burton-upon-Trent Electric Lighting Order—Municipal Borough of Burton-upon-Trent; The Corporation; Messrs. Dyson and Co., 24, Parliament-street, S.W.

Bury Electric Lighting Order—Municipal Borough of Bury; The Corporation; Messrs. Lewin, Gregory, and Anderson, 13, King-street, Whitehall, S.W.

Cambridge Electric Lighting Order—Borough of Cambridge; The Corporation; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.

Chatham, Rochester, and District Electric Lighting Order—Portions of the Parishes of Frindsbury, Strood, St. Nicholas and St. Margaret's, Rochester, Chatham and Gillingham; Chatham, Rochester, and District Electric Lighting Company, Limited; C. E. Baker, Esq., 22, Great George-street, S.W.

Cheltenham Electric Lighting Order—A portion of the Municipal Borough of Cheltenham; The Corporation; Messrs. Wyatt and Co., 28, Parliament-street, S.W.

Chester Electric Lighting Order—City of Chester; The Corporation; Messrs. Martin and Leslie, 27, Abingdon-street, Westminster, S.W.

Coatbridge Electric Supply Order—Burgh of Coatbridge; Scottish House-to-House Electricity Company, Limited; Messrs. Wyatt and Co., 28, Parliament-street, S.W.

†Crompton Electric Lighting Order—Urban Sanitary District of Crompton; The Local Board; J. C. Ball, Esq., 16, Parliament-street, S.W.

Darlington Electric Lighting Order—A portion of the Municipal Borough of Darlington; The Corporation; Messrs. Durnford and Co., 38, Parliament-street, S.W.

Derby Corporation Electric Lighting Order—Municipal Borough of Derby; The Corporation; Messrs. R. W. Cooper and Sons, Westminster-chambers, 7, Victoria-street, S.W.

Dover Electric Lighting Order—Borough of Dover; The Corporation; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.

*Dundee Electric Lighting Order—Parliamentary Burgh of Dundee; The Gas Commissioners and Commissioners of Police; Messrs. W. Robertson and Co., 45, Parliament-street, S.W.

Eastbourne Electric Supply Order—Borough of Eastbourne; Eastbourne Electric Light Company, Limited; Messrs. Wyatt and Co., 28, Parliament-street, S.W.

Fleetwood Electric Lighting Order—Urban Sanitary District of Fleetwood; Fleetwood Improvement Commissioners; J. C. Ball, Esq., 16, Parliament-street, Westminster, S.W.

Galway Electric Lighting Order—District over which the Galway Town Improvement Commissioners are the Urban Sanitary Authority; Galway Electric Company; Messrs. Valpy, Chaplin, and Peckham, 19, Lincoln's-inn-fields, W.C.

*Glasgow Electric Lighting Order—City and Royal Burgh of Glasgow; The Gas Commissioners; Messrs. Martin and Leslie, 27, Abingdon-street, Westminster, S.W.

(* Still under consideration. † Provisional order has been granted, but the promoters wish to withdraw it).

Great Yarmouth Electric Lighting Order—Borough of Great Yarmouth; The Corporation; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.
Hastings and St. Leonards-on-Sea Electric Supply Order—Borough of Hastings (including St. Leonards-on-Sea); Hastings and St. Leonards-on-Sea Electric Light Company, Limited; Messrs. Wyatt and Co., 28, Parliament-street, S.W.
Hastings Electric Lighting Order—Municipal Borough of Hastings (certain public purposes only); The Corporation; Messrs. W. and W. M. Bell, 27, Great George-street, S.W.
Hove Electric Lighting Order—District and Parish of Hove; Hove Commissioners; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.
Huddersfield Electric Lighting Order—County and Municipal Borough of Huddersfield; The Corporation; Messrs. Dyson and Co., 24, Parliament-street, S.W.
*Kelvinside Electric Lighting Order—District of Kelvinside; Kelvinside Electricity Company, Limited; Messrs. Grahames, Currey, and Spens, 30, Great George-street, Westminster, S.W.
Kingston-upon-Hull Electric Lighting Order—Municipal Borough of Kingston-upon-Hull; The Corporation; Messrs. Martin and Leslie, 27, Abingdon-street, Westminster, S.W.
Lancaster Electric Lighting Order—Municipal Borough of Lancaster; The Corporation; Messrs. Hargreaves, Crowther, and Jordan, 9, Bridge-street, Westminster, S.W.
Leicester Electric Lighting Order—Municipal County Borough of Leicester; The Corporation; Messrs. Dyson and Co., 24, Parliament-street, S.W.
Malvern Electric Lighting Order—Local Government District of Malvern; The Local Board: Messrs. Ellis, Munday, and Bartrum, College-hill-chambers, 23, College-hill, E.C.
Manchester Electric Lighting Order—A portion of the City of Manchester; The Corporation; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.
*Manchester, Salford, and District Electric Supply Order—Manchester House-to-House Electricity Company, Limited; Messrs. Wyatt and Co., 28, Parliament-street, S.W.
Morecambe Electric Light and Power Order—A portion of the District of the Morecambe Local Board; Messrs. T. R. Andrews and T. Preece; Messrs. Torr and Co., 19, Parliament-street, S.W.
Northampton Electric Lighting Provisional Order--Municipal Borough of Northampton and parts of the Rural Sanitary Districts of the Northampton Union and the Hardingstone Union; Northampton Electric Light and Power Company, Limited; Messrs. Deacon and Co., 4, St. Mary Axe, E.C.
Nottingham Electric Lighting Order—Borough of Nottingham; The Corporation; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.
Oldham Electric Lighting Order—Borough of Oldham; The Corporation; Messrs. Dyson and Co., 24, Parliament-street, S.W.
Oxford Electric Lighting Order—City of Oxford; Electric Installation and Maintenance Company, Limited; Messrs. Walter Webb and Co., 23, Queen Victoria-street, E.C.
Plymouth and District Electric Supply Order—County Borough of Plymouth; Devon and Cornwall Electricity Supply Company, Limited; Messrs. Wyatt and Co., 28, Parliament-street, S.W.
Portsmouth Electric Lighting Order—Municipal Borough of Portsmouth; The Corporation; Messrs. Sherwood and Co., 7, Great George-street, S.W.
Preston Electric Lighting Order—A portion of the Parish of Preston; National Electric Supply Company, Limited; Messrs. Learoyd, James, and Mellor, 12, Coleman-street, E.C.
Preston and Fulwood Electric Supply Order—County Borough of Preston, the Township of Fulwood, the District of the Fulwood Local Board; and the District of the Preston Union Rural Sanitary Authority; Lancashire and Cheshire House-to-House Electricity Company, Limited; Messrs. Wyatt and Co., 28, Parliament-street, S.W.
Salford Electric Lighting Order—Municipal County Borough of Salford; The Corporation; Messrs. Dyson and Co., 24, Parliament-street, S.W.
Sevenoaks Electric Lighting Order—Local Board District of Sevenoaks; The Electric Trust, Limited; Messrs. Wyatt and Co., 28, Parliament-street, S.W.
Stafford Electric Lighting Order—Municipal Borough of Stafford; The Corporation; Messrs. Byrne and Blakiston, 14, Bell-yard, Temple Bar, W.C.
Stockton-on-Tees Electric Lighting Order—Municipal Borough of Stockton-on-Tees; The Corporation; Messrs. Dyson and Co., 24, Parliament-street, S.W.
Tiverton Electric Lighting Order—A portion of the Municipal Borough of Tiverton; The Corporation; Messrs. Rees and Frere, 13, Great George-street, S.W.
Tunstall Electric Lighting Order—Local Board District of Tunstall; The Electric Trust, Limited; Messrs. Wyatt and Co., 28, Parliament-street, S.W.
Walsall Electric Lighting Order—Borough of Walsall; The Corporation; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.
Wigan Electric Lighting Order--Borough of Wigan; The Corporation; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.
Windsor and Eton Electric Lighting Order—Parish of New Windsor, and a portion of the District of the Eton Rural Sanitary Authority; Windsor and Eton Electric Light Company, Limited; Mr. Sydney Morse, 4, Fenchurch-avenue, E.C.
Woking Electric Supply Company Order—Parish of Woking; Woking Electric Supply Company, Limited; Messrs. Bircham and Co., 46, Parliament-street, S.W.
Wolverhampton Electric Lighting Order—Municipal Borough of Wolverhampton; The Corporation; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.
Worcester Electric Lighting Order—City of Worcester; The Corporation; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.
Wrexham Electric Light and Power Order—Municipal Borough of Wrexham; Wrexham and District Electric Supply Co., Limited; Messrs. Sherwood and Co., 7, Great George-street, S.W.
York Electric Lighting Order—City of York; The Corporation; Messrs. Sharpe and Co., 9, Bridge-street, Westminster, S.W.

London and Suburbs.

*City of London Electric Lighting Order—A portion of the City of London; Brush Electrical Engineering Company, Limited; Sydney Morse, Esq., 4, Fenchurch-avenue, E.C.
*City of London Electric Lighting Order—A portion of the City of London; The Laing, Wharton, and Down Construction Syndicate, Limited; Henry F. Kite, Esq., 11, Queen Victoria-street, E.C.
Crystal Palace and District Electric Lighting Order—Portions of following districts—viz.: Parishes of Lambeth and Camberwell, District of Lewisham District Board of Works, of Beckenham Local Board, and Borough of Croydon; Electric Installation and Maintenance Company, Limited; Messrs. Walter Webb and Co., 23, Queen Victoria-street, E.C.
Lambeth Electric Supply Order—Parish of St. Mary, Lambeth; House-to-House Electric Light Supply Company, Limited; Messrs. Wyatt and Co, 28, Parliament-street, S.W.
London Electric Supply Corporation Electric Lighting (Metropolitan) Order—Parish of Camberwell (part of), Parish of St. George-the-Martyr, Southwark; London Electric Supply Corporation, Limited; Messrs. Deacon and Co., 4, St. Mary Axe, E.C.
Metropolitan Electric Supply Company, Limited, Lighting Order—Parish of Paddington; Metropolitan Electric Supply Company, Limited; Messrs. Bircham and Co., 46, Parliament-street, Westminster, S.W.
North London Electric Supply Order—Parish of Islington; House-to-House Electric Light Supply Company, Limited; Messrs. Wyatt and Co., 28, Parliament-street, S.W.
St. James's Electric Lighting Order—Parish of St. James's, Westminster; St. James's and Pall Mall Electric Light Company, Limited; Sydney Morse, Esq., 4, Fenchurch-avenue, E.C.
Wandsworth District Electric Supply Order—District of the Wandsworth District Board of Works: Messrs. A. and S. Gatti; Messrs. Wyatt and Co., 28, Parliament-street, S.W.

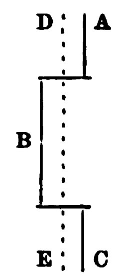
The following orders with relation to the metropolis had been previously granted. We give the title of order, and how it is dealt with.

House-to-House Electric Light Supply Order—The order was granted for two areas within the Parish of Kensington, St. Mary Abbot.
Kensington and Knightsbridge Electric Lighting Order—Order granted for a portion of the Parish of Kensington, St. Mary Abbot, and the detached portion of the Parish of St. Margaret, Westminster.
London Electric Supply Corporation Electric Lighting Order—Order granted for the following Districts: Parishes of St. James, Westminster; St. George, Hanover-square; Chelsea (except the detached portion); Rotherhithe; Clerkenwell; Bermondsey; St. Mary, Newington; Lambeth (the portion north of Westminster-bridge-road); St. Martin's-in-the-Fields (the portion west of St. Martin's-lane and south of the Strand); the United Parishes of St. Margaret and St. John-the-Evangelist, Westminster (the portion north of Victoria-street, Parliament-square, and Bridge-street). The Districts of the following Boards of Works: Greenwich District, St. Olave District, St. Saviour's District.
Metropolitan Electric Supply Company (Mid-London) Lighting Order—Granted for the Districts of the following Boards of Works: St. Giles' District, Holborn District, Strand District.
Metropolitan Electric Supply Company (South London) Lighting Order—Granted for the Parish of Lambeth and the Parishes of Clapham and Streatham, which form part of the District of the Wandsworth Board of Works.
Metropolitan Electric Supply Company (West London) Lighting Order—Granted for the Parish of St. Marylebone.
Notting Hill Electric Lighting Order—Granted for a portion of the Parish of Kensington, St. Mary Abbot.
St. Martin's and Strand Electric Lighting Order—This order was applied for by the Electrical Power Storage Company with a view to the formation of a separate company for the purposes of the order. This company was eventually registered under the title of the Electrical Supply Corporation, Limited, to whom, with the approval of the Vestry of St. Martin's-in-the-Fields, the order was granted. As the Strand Board of Works objected to the grant of the order, the Board of Trade declined to include the district of that Board in the area of supply.
South Kensington Electric Lighting Order—Granted for a portion of the Parish of Kensington, St. Mary Abbot.
Westminster Electric Lighting Order—Granted for the Parish of St. George, Hanover-square, and the portion of the United Parishes of St. Margaret and St. John-the-Evangelist, Westminster, lying to the south of the line of the Metropolitan District Railway.

PHYSICAL SOCIETY.—June 20.

Prof. W. E. Ayrton, F.R.S., President, in the chair.

Mr. C. V. Boys read a paper on "**The Measurement of Electromagnetic Radiation**," by himself, Messrs. A. E. Briscoe and W. Watson. When Mr. Gregory described his new electric radiation meter on November 1st, 1889, one of the authors said that the observed effect might be due to some cause other than expansion by heating, and that if it was a true heating effect it might be measured thermally. The present communication describes experiments undertaken to investigate the question. The first method employed was developed from the idea that if two fine wires be placed near together, and both act as resonators to a primary oscillator, the electrodynamic attraction caused by the electric currents up and down the wires, and the electrostatic repulsion between the charges on them, might result in the relative motion of the two wires. From theoretical considerations based on the assumption that the currents are harmonic in time and space, the authors inferred that the electrodynamic effect would preponderate at the middle of the wires, whilst the electrostatic repulsion would be greatest at the ends. To cause the attractions and repulsions to conspire, cranked resonators, ABC (as in the figure), were made;



one was fixed, and the other suspended by a quartz fibre, to turn about a middle line, D E. These were enclosed in a glass vessel, and on starting the oscillator a turning movement was observed in a direction opposite to that expected. This motion was eventually traced to the electrostatic influence of the oscillator, for although the imperfectly conducting surface of the glass acted as a perfect screen from such action when the potentials of the oscillator were varied slowly, it did not do so for changes occurring about 500 million times per second. After adopting means to avoid this disturbance and constructing lighter resonators, the experiments were repeated with negative results. From the dimensions of the quartz fibre used it was estimated that a force of 158 millionths of a grain could have been detected with certainty; this would have corresponded to about $\frac{1}{500}$ of an ampere in each resonator. It is hoped that by further increasing the sensitiveness of the apparatus and using parabolic reflectors the effect sought for may be detected. In the second method of attacking the subject, a Joule's dynamic air thermometer was employed. This consisted of a glass tube with a partition along the middle extending nearly to the ends. If one side of the tube be warmed, convection currents circulate and deflect an index placed in the stream. A small mirror suspended about one edge and counterpoised was used for an index, and was so sensitive that it was impossible to get the air still enough by any ordinary method of screening. However, by the ingenious device of putting the thermometer within a larger tube kept rotating by clockwork, the difficulties were surmounted. A doubled wire placed in one side of the thermometer served as resonator, and on starting the oscillator a large deflection resulted. A similar deflection was caused by applying about one-third of a volt to the ends of the wire. This proved that the effect observed by Mr. Gregory is due to heating. The least rate of heating observable with the air thermometer was found to correspond to one calorie (gramme-water-centigrade) per 24 hours in the whole tube, or one calorie per centimetre of wire in 103 days. **Dr. Lodge** asked Sir William Thomson whether, when electric pulses travel along parallel wires with the velocity of light, any action could exist between them, for two charged spheres travelling together at that velocity exert no mutual attraction or repulsion. In reply, **Sir William** said he was inclined to think Mr. Boys' treatment of the subject was in the main correct, but it was quite possible that at such velocities the ordinary laws might be modified by the fact that the time taken for the force to be propagated from wire to wire is comparable with that required for the pulse to travel the whole length of the wire. As an example of the peculiar effects of rapid discharges, he said he had seen two copper wires which had been flattened against each other by lightning. **Mr. Boys** thought that in his resonators a condition analogous to stationary waves would exist, for the pulses are reflected from the ends. **Dr. Lodge** said he had that afternoon observed the action of parallel strips when Leyden jar discharges were passed through them. The strips gave a kick at each discharge. **Mr. Gregory** mentioned that in trying to increase the sensitiveness of his meter so as to measure the variation with distance, he had found that two resonators in proximity interfered with each other. He had, however, succeeded in increasing the sensibility about fivefold. **Prof. Worthington** asked if it was possible to measure the energy of the oscillator, and also whether the quantity caught by the resonator could be estimated from the solid angle it subtended at the source of energy, wherever that might be. **Prof. Perry** considered it easier to infer the energy of the source from that received by the resonator. **Dr. Lodge** said the energy of the source could be easily measured. The power radiated was enormous whilst it lasted, vastly exceeding that of tropical sunshine; and if it could be made continuous the apparatus would soon be red-hot. The energy radiated, he said, converges on the resonators, and hence the solid angle method of estimating the amount received would be erroneous. Moreover, the source was not at the oscillator, but at a quarter wave-length from it, and most of the energy returns to the oscillator. Only a small fraction is splashed off and sent into space. Small oscillators radiate powerfully because the quarter wave-lengths are small, whereas the slow oscillators or alternators used commercially radiate very little of their energy. The exact law of variation of intensity of radiation with distance was rather complicated, but the theory had been completely worked out by Stokes in 1848. **Mr. Blakesley** thought the energy that returns to the oscillator would be available for subsequent radiations. **Dr. Lodge** pointed out that wires or other resonators placed within the quarter wave-length would intercept part of the returning energy.

Two communications, "**Notes on Secondary Batteries**," by **Dr. Gladstone** and **Mr. Hibbert**, and "**An Easy Rule for Calculating Approximately the Self-Induction of a Coil**," by **Prof. J. Perry**, were taken as read. In the first of these, the authors show cause for believing that the beneficial effect produced by adding sodium sulphate to the ordinary electrolyte is due to its power to diminish local action between the electrolyte and different parts of the lead plates. As regards the chemical actions which take place during the working of ordinary cells, they see no reason to doubt the view put forward by one of them in 1882, that the substance produced in the voltaic reaction is ordinary lead sulphate, $PbSO_4$. They also conclude that the high E.M.F. of a cell, immediately after stopping the charging current, is due to the inequality of acid strength near the two plates, and the gradual fall of E.M.F. is caused by the equalisation of strength produced by diffusion. Prof. Perry's rule relates to hollow cylindrical coils, and is expressed by the following formula:

$$L \text{ (in secohms)} = \frac{n^2 a^2 \div 10^7}{1{\cdot}844\,a + 3{\cdot}1\,c + 3{\cdot}5\,b},$$

where n = number of windings,
a = mean radius of winding in centimetres,
b = axial length,
c = radial depth of winding,

and b and c are less than $\frac{a}{2}$

The time-constant of such a coil is given in terms of the volume of copper (V^1) in cubic centimetres by

$$\frac{L}{R} = \frac{V^1 \div 1000}{{\cdot}728\,a + 1{\cdot}33\,c + 1{\cdot}5\,b},$$

and the conditions for making this small are pointed out in the paper.

NEW COMPANIES REGISTERED.

Beales, Limited.—Registered by Bolton and Mote, 11, Gray's-inn-square, W.C., with a capital of £75,000 in £1 shares. Object: to acquire the businesses of a public caterer, restaurateur, general provision dealer, licensed victualler, and electric light and power contractor now carried on under the style of W. Beale and Co., at 370, 372, and 464, Holloway-road, Islington. The first subscribers are:

	Shares.
W. Carden, Loraine-place, 247, Holloway-road	1,000
H. S. Shipton, Ellendale, Crescent-road, Crouch-end	250
R. Berridge, 15, Highbury-grove, N.	250
W. Beale, 370, Holloway-road.....	250
J. Humphries, Westfield, Turnpike-lane, Hornsey, N.	250
W. E. Beale, 4, Tollington-road, Holloway......... ..	250
H. W. Mote, 75, Isledon-road, Holloway..............	20

There shall not be less than three nor more than five Directors. The first are W. Carden, H. S. Shipton, R. Berridge, and W. Beale. Qualification, 250 shares. Remuneration: the Directors shall, subject as hereinafter provided, be entitled to receive for their remuneration out of the funds of the Company, before any dividend is declared, a sum not exceeding £250 per annum for their attendance at the Board meetings. Two guineas shall be the maximum sum for each attendance, except that the Chairman shall be entitled to a double fee for each attendance, but the Directors may amongst themselves determine whether the payment for each attendance shall be less than two guineas. This article is, however, subject to the right of the Company to determine in any general meeting what other (if any) amount shall be paid or allowed to the Directors for their remuneration, and under and subject to what conditions (if any) the same shall be so paid or allowed.

International Okonite Company, Limited.—Registered by Parker, Garrett and Parker, St. Michael's Rectory, Cornhill, with a capital of £340,000 in £10 shares. Object: to carry into effect an agreement made between Woodhouse and Rawson United, Limited, and the above company; to carry on business as electricians, engineers, merchants, and any business calculated to enhance the value of the Company's property. The first subscribers are:

	Shares.
F. Spooner, 83, Rendlesham-road, Clapton	1
J. Beaumont, 9, Daneville-road, S.E.......................	1
H. E. Smith, 26, Park-place, Leyton	1
H. C. Newton, 121, Avenue-road, Highbury..	1
J. J. Standen, 60, Moray-road, N.	1
W. Dauncey, 6, Lexham-gardens, W.......	1
A. Stevens, 4, Trafalgar-square	1

The Directors shall consist of residents in the United Kingdom not exceeding six, and in the United States of America not exceeding five. The first in the United States of America shall be F. Cazenove Jones, H. Durant Cheever, W. L. Candee, J. H. Cheever, and J. L. Martin. The first Directors in the United Kingdom to be appointed by the subscribers to the memorandum of association. Qualification, £500. The Directors resident in the United Kingdom shall be entitled to £1,500, divisible, and 3 per cent. on net profits other than those made by the American branch of the business. The Directors in the United States of America shall be entitled to 5 per cent. of the net profits made in the American branch of the business; the same to be divisible.

Thetford Electric Light and Power Company, Limited.—Registered by R. Jordan, 120, Chancery-lane, W.C., with a capital of £5,000 in £10 shares. Object: to carry on the business of electricians, mechanical engineers, etc. There shall not be less than two nor more than four Directors. The first are Mr. C. Burrell, jun., Mr. R. G. Burrell, Mr. F. J. Burrell, and Mr. W. Jackson. Qualification, £50. Remuneration to be determined in general meeting.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the week ended June 27 amounted to £4,169.

West Coast of America Telegraph Company.—The receipts for the month of June amounted to £5,475.

Eastern Telegraph Company.—The traffic receipts for June were £51,019, as against £44,805 for the same period of 1889, or an increase of £6,214.

West India and Panama Telegraph Company.—The receipts for the half-year ended June 30 show an increase of £353 as compared with the corresponding period.

Eastern Extension Telegraph Company, Limited.—An interim dividend for the quarter ended March last of 2s. 6d. per share has been declared by the Board of this Company, payable on the 15th instant.

Western and Brazilian Telegraph Company, Limited.—The receipts for the week ended June 27, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,216.

National Telephone Company, Limited.—The Directors recommend a dividend on the ordinary capital for the half-year ending April 30 at the rate of 6 per cent. per annum, placing £40,000 to reserve, and carrying forward about £11,000.

Eastern Extension, Australasia, and China Telegraph Company, Limited.—This Company notify that the coupon on their 5 per cent. Australian Government subsidy debentures, due on July 1, will be paid on and after that date at the banking-house of Messrs. Barclay, Bevan, and Co., 54, Lombard-street, E.C. The Company have declared an interim dividend of 2s. 6d. per share, tax free, payable on 15th inst.

PROVISIONAL PATENTS, 1890.

JUNE 24.

9773. **A system for working punkahs by electricity.** Robert Thornton Moore, Royal Artillery, Colombo, Ceylon.

9780. **Improvements in electric railway signals.** William James Smith and James Walter Fox, 46, Lincoln's-inn-fields, London. (Complete specification.)

9786. **An improvement on electric incandescent lighting, called "The non-consuming glow light filament."** Louis Héndlé and Edward Schuberth, 12, Phœbe-terrace, Pevensey-road, Forest Gate.

9796. **Improvements in and relating to electric circuit controlling apparatus.** Edward Ruthven Gill, junior, 77, Chancery-lane, London. (Complete specification.)

9797. **Improvements in and relating to electric mechanical combination locks and magnetic power equalizers.** William Walter Alexander, 77, Chancery-lane, London. (Complete specification.)

9814. **Improvements in apparatus for electrically firing guns.** Richard Morris, 28, Southampton-buildings, London.

9820. **Improvements relating to electric arc lamps.** John Kent, 166, Fleet-street, London.

JUNE 25.

9840. **Improvements in astatic galvanometers.** Robert Drysdale and Henry Burman Lowe, 7, Cherry-street, Birmingham.

9857. **Improvements relating to welding, soldering, brazing, and otherwise working metals by electricity, and to apparatus therefor.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

9861. **Improvements in electrical storage batteries.** Alfred Julius Boult, 323, High Holborn, London. (Donato Tommasi and Charles Therye, France.)

9887. **Improvements in electrical controlling apparatus for use in connection with torpedoes.** Siméon de Kojine, 45, Southampton-buildings, London.

JUNE 26.

9888. **Improvements in connection with electric ships, binnacle, side, and indicator lamps.** Thomas William Watson and Arthur Henry Watson, 4, Pall Mall, London.

9904. **Improvements in armatures for electrical apparatus such as dynamos, motors, and transformers.** William Henry Clarke, 46, Lincoln's-inn-fields, London.

9917. **An improved electrical circuit closer.** Alexander Melville Clark, 53, Chancery-lane, London. (R. O. G. Drummond, South Africa.)

9932. **Improvements in electrically-controlled lubricators and oil cups.** Henry Harris Lake, 45, Southampton-buildings, London. (Thomas Joseph McTighe, United States.) (Complete specification.)

9937. **Making lead pipe or covering insulated electrical conductors with lead sheaths.** Lewis Wood Tracy and James Elnathan Grannis, 24, Southampton-buildings, London.

JUNE 27.

9956. **Improvements in heating by electricity.** Rankin Kennedy, 10, India-street, Kilmarnock.

9991. **Improvements in or connected with the manufacture of iron by electrolysis.** Thomas Parker, 47, Lincoln's-inn-fields, London.

JUNE 21.

10010. **An electrical turn-over time glass.** William Parnall, 108, Victoria-street, Bristol.

10025. **Improvements in electric safety fuses.** William Morris Mordey, 46, Lincoln's-inn-fields, London.

10038. **Improvements in the electrolytic treatment of metals.** Alexander Watt, 81, Fernlea-road, Balham.

10044. **Improvements in primary batteries and in apparatus connected therewith.** Sir Charles Stewart Forbes, 21, Finsbury-pavement, London.

JUNE 30.

10064. **Improvements in electric light fittings.** Thomas Gardiner Marsh and George Thomas Barlow, Lytham, Lancs.

10076. **Improved safety connections or couplings for electric conductors.** Robert Howe Gould and Theodor Gottschalk, 8, Quality-court, London. (Complete specification.)

10090. **Improvements in dynamo and electric motor machinery.** James Alfred Briggs, 30, Dewhurst-road, Hammersmith, London.

10100. **Improvements in and relating to electrical indicators.** Arthur Millward Flack, 26, Hartham-road, West Holloway, London.

10122. **Improvements in and relating to heating apparatus for use on electric railways.** Mark Wesley Dewey, 45, Southampton-buildings, London.

10123. **Improvements relating to welding, soldering, and otherwise working metals by electricity.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Date applied for under Patents Act, 1883, Section 103, 11th December, 1889, being date of application in United States.) (Complete specification.)

10124. **Improvements in electric heating apparatus.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

SPECIFICATIONS PUBLISHED

1889.

10878. **Electric telephones.** Morison. 11d.

10940. **Electric couplings.** Hollins. 8d.

12444. **Telephone systems.** Smith. 8d.

14656. **Electric glow lamps.** Bernstein. 6d.

1890.

4087. **Secondary voltaic batteries.** Cheswright. 6d.

5335. **Electrical conductors.** Lake (Stetson). 8d.

5343. **Telpherage systems.** Lake (Maynadier). 8d.

6811. **Telephones.** Vogel and Calkins. 6d.

6893. **Incandescent light.** Von der Poppenburg. 4d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2¾
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	10

NOTES.

Magnetite.—A discovery of a large deposit of magnetite of fine quality has been made on the Antler river, about 100 miles northwest of Port Arthur, U.S.A. The ore is being treated with a magnetic separator.

Thomson-Houston Tramways.—The West End Company, of Boston, U.S., still continue to increase their electric lines, and are now laying new rails. Current is being regularly supplied from the Edison electric station.

Duty on Electricity.—The Treasury of the United States have decided upon the question raised with reference to the transmission of electric force across the Niagara to Canada, that electricity does not rank among dutiable goods.

Fifty Per Cent. Increase.—The street railways of Milwaukee have abandoned the "bobtail car" with one conductor for handsome electric cars with a driver and conductor, and the receipts have already increased 50 per cent.

Electric Mining.—The application of electricity to mining operations is becoming such an important industry, that the Thomson-Houston Company are erecting a special building at Lynn, Massachusetts, for the manufacture of the apparatus.

Hastings.—Compliance with the standing orders of Parliament was proved last Friday in the case of the Electric Lighting Provisional Orders (No. 10) Bill, which confirms a provisional order of the Local Government Board empowering the Corporation of Hastings to light the town by electricity.

Popp System in Paris.—M. Victor Popp is applying for three concessions in Paris; one for the laying of electric light mains in the Place de la Bastille, a second for the Rue Feydeau, and the third for the right to run charging cables over or under the municipal conduits or along the pavement of the streets.

Electrical Activity.—Some idea may be gathered of the activity prevailing in electrical circles in the West of America from the fact that a Chicago firm, just started, secured in the first week of its organisation contracts for over 2,600 h.p. in engines for electric light divided amongst several central stations.

New Insulating Compound.—A new insulating material has just been invented, which consists of a covering of cotton and spun glass, jacketed with woven cotton dipped in paraffin. The material is said to be practically indestructible, and certainly it has every appearance of proving a good and enduring insulator.

Electric Locomotive.—During the experiments with navigable balloons at the military works at Meudon, says a Dalziel's message, a trial was made of a locomotive engine, 70 h.p., weighing only half a ton, and occupying a very small space. The motive power is electricity, and will work for 10 hours. The inventor is a M. Bernard.

Belfast.—The Belfast Harbour Commissioners having got a definite undertaking from the Board of Trade to insert in the Belfast Electric Lighting Provisional Order, 1890, the protective clause which they required, the Commissioners have withdrawn the petition which they presented to Parliament against the Bill confirming the said order.

Winchester.—The Corporation of Winchester recently discarded gas and took to oil on account of the exorbitant demands of the gas company. They are not content with their substitute, and have appointed a committee and tenders will be invited for the supply of electric light. Incandescent lamps of 20 c.p. appear to be the standard favoured for the public lighting.

Electricity at Work.—There are now in use in the United States more than 5,650 central electric stations for light and power. There are 210,000 arc lights, and 2,600,000 incandescent lamps. There were 59 electrical railways in operation in March last, and 86 roads in process of construction. The increase of capital in electrical investments during 1888 was nearly 70,000,000dols.

Nottingham University College.—At a meeting of the college committee of management, held at Nottingham on the 1st inst., Mr. William Robinson, M.E., senior demonstrator in electrical engineering and applied physics, and chief assistant to the principal of the City and Guilds of London Technical College, Finsbury, was unanimously elected professor of engineering at the University College, Nottingham.

Hong Kong.—The first ordinary meeting of the shareholders of the Hong Kong Electric Company, Limited, was held at the Hong Kong Hotel on the 24th May. Mr. H. L. Dalrymple presided, supported by W. H. Wickham (manager) and C. F. Harton (secretary). The chairman, after moving the report, said that they hoped that in about four months they would be in a position to start the lighting of the area at present arranged for with the Government.

Scotch Bills.—In the House of Lords on Tuesday, on the motion of Lord Balfour of Burleigh, the sessional order against a provisional order Bill originating in that House being read a first time after the 16th of May, was dispensed with in respect of a Bill to confirm certain provisional orders made by the Board of Trade under the Electric Lighting Acts 1882 and 1883, relating to Aberdeen, Dundee, Kelvinside, and Moss-side and Stretford; and the Bill was brought in and read a first time.

Accumulator Tenders.—We notice that M. Paul Gadot is advocating the use of auxiliary cars for street tramways to go in front of the cars and carry the accumulators, the motor being on the tramcar itself. As this method was first devised by Mr. Sandwell, of Victor Works, Holloway, and described and illustrated in this journal on May 17th, 1889, it will be interesting to hear what this latter gentleman has now to tell us upon the present position of this method of using accumulators for tramway work.

Economy of Electric Power.—In a certain building devoted to small manufacturing interests in Bridgeport, Connecticut, a 120 h.p. steam-engine was used to generate power. This power was delivered in such small units and through such a multiplicity of shafting, that the engine indicated 60 h.p. when not a machine in the building was in operation, the engine simply turning the shafting. An electric supply company heard of this and at once proceeded to sell the proprietor of the building 50 electric h.p., to do the work formerly done by the 120 h.p. engine—a clear saving of 60 per cent. Great is the economy of electricity.

Electric Light Fitting.—We have received from Messrs. Crosby, Lockwood, and Co. a copy of a new work on "Electric Light Fitting, a Handbook for Working Electrical Engineers," with practical notes on installation management, by John W. Urquhart. The work deals with practical details of central station work, localising faults, treatment of accumulators, switchboard, and testing work, wiring for arc light and incandescent light, ligh-

understands that the coast is clear, and turns on his current without fear of accident to any of the linemen. This system may be worthy of imitation in England in stations using high-tension currents when much manipulation of the lines, connections, or switches is necessary.

Power in Paris.—M. Michel Levy, in a report upon the question of the regulation of electric works in Paris, gives the following figures, showing the amount of power used in these stations. The total force in actual working at the present time is over 10,000 h.p., representing one-sixth of the total motive force used in the department of Seine. Under the heading of public central electric light stations, it appears there are 12 stations, producing 5,000 h.p., consuming 12,500 tons of coal annually. Of these, 10 comprise stations of more than 100 h.p. Under the head of electric installations supplying separate or private buildings, there are 24 stations, producing 5,000 h.p., consuming 12,500 tons. Of these, 19 producing more than 100 h.p. each. Besides these there are the stations for the supply of power, of which there are 10, producing 3,500 h.p., consuming 9,500 tons a year. The stations producing more than 100 h.p. each are proposed to be classed as unhealthy, inconvenient, and dangerous, on account of the inconvenience experienced from smoke, noise, and vibration.

Weymersch Battery at Covent Garden.—Through the invitation of the Weymersch Battery Company we were enabled, last week, to inspect and examine the effect of their battery in actual work in a promising installation. The battery has been placed in the "foyer" or smoke-room of the Covent Garden Theatre during the run of Mr. Augustus Harris's Italian opera season. The room, which is tastefully decorated with exotic plants, is lighted by two electroliers carrying 12 lamps each and several brackets and ornamental standards. Some 40 lamps in all, of 8 c.p. and 50 volts, are kept lighted, and burn with a steady and brilliant light. The supply is obtained direct from a set of 16 Weymersch batteries, of six cells each. These are charged every other day by a lad taking about 20 minutes or half an hour to charge by means of the arrangement of casks and pipes, which is part of the system. Particulars of the consumption of the battery were recently given in a series of careful tests. The installation is evidently successful, and will no doubt result in enquiries for similar cases where a battery may be found useful.

Blathy Alternate-Current Meter.—Messrs. Ganz and Co., of Buda-Pesth, are now manufacturing the alternate-current meter designed by Mr. Blathy, lately tested by the international committee of experts at Frankfort in November last. The meter is formed of a disc of copper mounted upon a vertical axis capable of being rotated around this axis, and passing between the curved armatures of two electromagnets. These, placed at an angle of 90deg. to each other, are mounted one in series and the other in shunt to the main circuit. From this arrangement the copper disc is submitted to the simultaneous action of two fields of force, reciprocally proportional to the strength of the main current and the difference of potential at the terminals. The reaction of the electromagnets upon the disc gives rise to induced currents on the mass of copper and puts it into movement; but the rotation of the disc produces currents in the opposite direction to the first, which oppose the movement. These act as speed regulators, and allow the apparatus to rotate at a speed proportional to the amounts to be measured. A train of gear, put in motion by the rotation axle, shows, by a simple reading, the total quantity of energy consumed. The Blathy meter starts with a current of ·25 ampere, and the readings are correct to within 3 per cent.

Lighthouse Arc Lamps.—Alluding to the loss of light from electric lamps in a fog as compared with the yellow gas light, it is suggested that the loss is owing to the blueness of the fog or mist; the electric light merely intensifying the blueness, while the gas still pierces the gloom. If the blue electric light were changed from blue to yellow before leaving the lighthouse, or, better, make the electric light one to be varied in colour at will, or according to the state of the atmosphere, then, even though several thousands of candle-power were absorbed, the light would be seen at a much greater distance even than the gas in a foggy night. It is suggested that the inauguration of a series of tests and experiments with different lights, surrounded by different coloured transparent films, and under the various conditions of the atmosphere, should lead to useful results. We think the attention of lighthouse authorities ought to be called to the greatly-increased lighting power, and this of a yellower character, experimentally obtained by the introduction of hydrocarbon vapour in the arc by the use of the Saunderson arc lamp carbons recently described, and we should be glad to hear if any tests have been made with these carbons for lighthouse purposes, and the results.

Metropolitan Stations.—In various parts of London may now be seen large, tall, and white chimneys standing up above the surrounding roofs, from which whiffs of white steam are gently rising. These are the chimneys of the Metropolitan Electric Supply Company's central stations, of which there are now three actually working—in Sardinia-street, in Rathbone-place, and in South-mews, Manchester-square. The first we have already alluded to, and it has been working for some time. The second, that in Rathbone-place, is being rapidly transformed into a similar station to the other, fitted with Willans engines and Lowrie-Parker alternate-current dynamos, part of which are working. The third, in Manchester-square, is just started partially. The workmen are still hard at work laying foundations, erecting dynamos and engines, and fitting switchboards. Four out of the 10 sets of engines and dynamos are now in working order, and two of them are regularly supplying some 1,500 lamps. The engine and dynamos are similar to those at Rathbone-place—Lowrie-Parker dynamos, coupled direct to Willans engines. The station at Manchester-square is a separate complete building, and will be in full working order before long. The dynamos are made at the Electric Construction Works at Wolverhampton.

Electric Fishing.—Experiments recently made by the Liverpool marine biologists in the application of electric light to sea-fishing, have attracted considerable notice amongst the industry. The progress they have made has been highly encouraging. Some time ago they discovered that "if an electric light were lowered into the sea inside a tow net they secured more living things than they would have done without the light." But, although the bearing of this discovery upon the fishing industries is palpable enough, the biologists were not content, and they have just tried a new plan. In a quiet Carnarvon bay they employed the dynamo of the salvage steamer "Hyœna," but instead of putting the light in the net "they lowered the marine lamp into the water," and, with small nets, scooped in the fish and crustacea which were attracted to the illuminated place. The experimenters are convinced—to use their own words—that "the electric light has a large future before

it in the fishing trade," and there is no doubt the idea contains within itself great possibilities. At present miles of lines and netting, costing hundreds of pounds, are employed, but in the near future each boat may require only a set of simple electric lamps, with a few hand nets. The harvest of the sea will then be reaped with less expense, trouble, and danger, and consequently with more profit to the fishermen.

Epstein Process for Accumulator Plates.—A method of manufacture of accumulator plates, described by M. Epstein, has the advantage of reducing the time of treatment without affecting the solidity of the plates. Lead plates are immersed in a vessel containing water acidulated with one hundredth part of nitric acid. The water is kept in ebullition until the plates are covered with a dark grey coating, when they are withdrawn, and allowed to dry. They then present a yellow-grey tint, due to a lead compound, very adhesive and insoluble in acidulated water, at the same time incapable of absorbing gases. This first operation completed, the positive and negative plates are formed. Into water acidulated with sulphuric acid as commonly used are plunged two groups of plates, connected respectively to the terminals of the dynamo, and the current is passed until a disengagement of gas is produced at the electrodes. The hydrogen coming from the positives reduces the red coating of the negatives to spongy lead; an abundant disengagement of hydrogen around the negatives shows the end of the operation, and the colour of the positives should pass from a reddish-brown to a greyish-blue. The plates are then formed and ready for use. A few hours is sufficient to form a double set of plates, and it is not necessary to reverse the current several times, as in the usual method of forming accumulator plates.

An Installation in Nine Hours.—In spite of all the inconvenience and lamentable incidents caused last week by the unfortunate gas strike at Leeds, it has at least done one good thing; it has provided an opportunity for at last testing the relative merits of its opponent, electricity, and has put the latter in the position to which it is entitled. The town was in darkness, and it was with the greatest difficulty some of the newspapers could be published at all. Mr. Wilson Hartnell, of Volt Works, Leeds, volunteered the services of an efficient staff to assist the *Yorkshire Post* out of the dilemma, and the management at once accepted the offer. Work was begun within a few minutes of one o'clock p.m., excavations were at once commenced in the basement to provide room for driving pulley and necessary foundations for dynamo, countershaft and pulleys had to be specially turned and bored respectively for necessary belts, and at 10.50 p.m. the dynamo started running with 40 lamps of 50 c.p. and 20 lamps of 16 c.p. in the composing-room, and six 100 c.p. in machine-room, the wiring for which was completed, and each lamp provided with suitable shade, in the short space of 5½ hours. The employés expressed their utter amazement, coupled with extreme satisfaction, at such a sudden transformation from the miserable wax candles to the electric light. It is certainly an instance of smart work, upon which Mr. Hartnell is to be congratulated.

Electrical Units.—We have received from the publishers of the *Western Electrician*, Chicago, a copy of the "Derivation of Practical Electrical Units," by Lieut. F. B. Badt and Prof. H. S. Cathcart, with 12 illustrations (75c.). The book first appeared as a series of articles in the above publication, and attracted a considerable amount of interest and appreciation in that form. These articles are now reprinted, bound in a handsome little volume, useful, and exceedingly interesting for reference. The idea of the work is a good one. The names of the electrical units are practically all taken from its pioneer workers distinguished in electrical science. To take the renowned men whose names are rendered more familiar by frequent use in actual work, to write their biographies in a simple straightforward style, and accompany them with large portraits cut from the best and most correct sources, has been the aim of the authors, and they have carried out this idea in a delightful and serviceable manner. The relation of the units to each other is explained and résumed in a table. Portraits of Weber, Gauss, Ampère, Coulomb, Volta, Ohm, Faraday, Watt, Joule, Dr. Werner von Siemens, Sir William Siemens, Daniell, and Jacobi are given. Prof. Cathcart adds a chapter upon the modifications of the practical electrical units, due principally to the variations of the unit of resistance, both as regards the volt and the numeric of a capacity, to explain what is often a source of perplexity to workers in the electrical field.

Bromley.—Messrs. Laing, Wharton, and Down have given notice to the Bromley Local Board of intended application to Parliament for a provisional order, under the Electric Lighting Act, and Mr. H. J. Lansbury, secretary to the local electrical syndicate, has informed the Board that the company propose a nominal capital of £10,000, and purpose both public and domestic lighting, under a contract with Messrs. Laing, Wharton, and Down. Mr. Lansbury maps out an experimental area for public lighting in which the syndicate would maintain 50 arc lamps at £22. 17s. per annum each. It is also stated that immediately the syndicate is in full working order, it will go before the ratepayers of Bromley and Beckenham for an additional capital of £15,000, and apply for a further provisional order extending the area. The present time is favourable, as the gas company have both raised the price of gas 3d. per 1,000, and also created considerable feeling against them by withdrawing a concession to their men made in November on the occasion of a strike. The Local Board have not as yet given public discussion to the application, but considering their quarrel with the gas company some time ago, which led to partial oil lighting, the advent of a new lighting syndicate should be favourably and helpfully received by the authority, if only on the ground of a healthy competition likely to keep the price within a fair and reasonable limit, as well as ensuring an efficient public light, which has not always been the case in the past.

Largest Boiler in the World.—At the electric lighting station on West Twenty-fourth-street, New York, what is described as the largest boiler in the world was tested a week or two ago. It is encased in a vertical shell ¾in. thick, and gives an assurance of 10 under a working pressure of 200lb. The tubes number 600, and are 3in. in diameter. Their length, if stretched out, would reach 7,200ft., or almost 1½ miles. They are twisted and penetrate the cylinder 1½ft. higher than the level from which they start. There is also an inner cylinder, which runs a short distance below the normal water level. It is open at the upper end, and short tubes lead it to the lower ends of the twisted tubes, into which they fit loosely. The feed water goes into the inner cylinder, and thence goes to the twisted tubes. In these, rapid circulation is obtained, because of its upward tendency and the fierce heat surrounding the tubes. The discharge of water and steam

goes into the space between the inner and outward cylinders. The rapid circulation is downward in the inner cylinder and upward in the intermediate space. The heating surface evaporates with a rate of 125lb. of coal per square foot of grate per hour, 6lb. of water per square foot of heating surface per hour requiring only five square feet of heating surface per horse-power, on a basis of 30lb. of water per horse-power and per hour. The whole boiler contains 6,000 square feet of heating surface, and is of 1,000 h.p. One hundred square feet is the area of the grate surface, being in the ratio of 60 for heating to one of grate surface, thus reducing escaping gases to the lowest practical temperature. Another of these boilers is now in course of construction.

Householders and the Electric Mains.—Supply companies must mind their P's and Q's with respect to the derangement of household economy incidental to the upheaval of streets and pavements. It would be a great pity if the public were brought to the idea the electric light companies were dilatory and inconsiderate of private feelings when laying their mains, or that arrangements were not being made for the keeping of a sufficient thoroughfare for passengers through the want of a few boards when the underground conduits are being made. A contrast to the action of the gas companies to the detriment of the electric light would be pitiable, and is, no doubt, quite avoidable. The subject was brought up by Mr. F. C. Burnand, in a characteristic letter to the *Times* last week, complaining of the derangement of his footway, on the eve of a party, by the Kensington and Knightsbridge Electric Company, and some good-humoured banter was indulged in to put the company on their good behaviour in the future. In this week's *Punch* he continues the onslaught through one of his cartoonists, who draws an awful picture of streets in a state of upheaval, pipes, coils of wire, and pickaxes lying about in chaos, with two or three villainous-looking navvies (they certainly can't be electrical wiremen—we know these are all a highly respectable and intelligent race of men) up to their waists in the troughs. The sketch is headed "Such an unexpected pleasure." The picture is to illustrate "The great advantage of bringing the electric light 'to your very doors,' without any previous notice, on the identical day when you are going to give a party, and your friends won't be able to get within some yards of your house. And then, so nice for the ladies if it rains." A word to the wise, especially if illustrated with a cartoon, should be enough.

Cable v. Electricity.—A decision has been made with reference to the tramways, or, as they are termed, street railroads, in America, which it is thought will have a yet still more encouraging effect upon electrical traction than even at present. This has been given in the case of the Third Avenue line, and lays down the ruling that the company can, by application to the Railroad Commissioners, employ electricity on its line in lieu of any of the methods specially mentioned in its charter, or in any other way take advantage of the opportunity of the progress of science. In commenting upon this, the *Electrical World* urges upon them the necessity of carefully weighing the advantages of electricity as against cable traction, which it would seem there is a tendency to adopt, and lays stress on some important points of advantage for the electrical method. Says our contemporary: "There is no doubt of the great usefulness of the cable as a factor in rapid transit, but it is open to objections which we think are serious enough to constitute formidable difficulties in the way of its use in New York. Chief among these is the inflexibility of a cable system as regards speed, from which results unquestionable danger in crowded streets. So long as the track is clear cable cars proceed with admirable regularity and without any special danger of accidents; but when, as so often happens, the pavements are blocked with vehicles of all sorts, the use of the cable becomes somewhat perilous. It is exceedingly difficult to work through a crowded street without means of backing a car and without thoroughly successful arrangements for running at a very much reduced speed. It is in just these particulars that electric traction is advantageous, inasmuch as by it it becomes possible to start, stop, or reverse the car with the greatest ease and security. Another characteristic disadvantage of the cable system is its inability to make up lost time. A cable car once delayed must stay delayed, while an electric car can very often make up a considerable amount of lost time by a somewhat increased speed in the open portions of the city. Again, if a cable breaks it is useless through its entire length, while it is of very rare occurrence that an electric system is crippled in any extensive way. The use of double cables will to a certain extent remedy this difficulty, but this is costly and inconvenient."

Elmore's Copper.—An exhibition of the products of Elmore's Patent Copper Depositing Company is being held at 56, Queen Victoria-street. These products comprise a vast variety of electro-deposited copper, ranging from immense polished tubes of some 2ft. diameter, of perfect circular section and exact sizes, through smaller tubes, rods, bars, strips, to wire for telegraph use, down to the finest-drawn hair-like filament, one hank of which is drawn through a diamond to the extraordinary length of 40 miles to the pound weight. It will be remembered that the process is that of depositing the copper direct upon a mandril and burnishing the copper down as deposited into a hard polished surface fit for immediate use. The action crushes the granular crystals, and forms a fine and hard tube when drawn from the mandril. The tubes are used for steam pipes, and for boiler tubes, and can be deposited upon rams, spindles, or propeller shafts, or can be drawn into wire of long lengths and great purity. For all sizes of pipes the average breaking stress is 25 tons per square inch of sectional area; each tube as made has a length cut off and tested, and the breaking stress as found is etched upon the tube. For copper wire the following method is adopted: The huge tube is cut spirally round and round into a square strip. This is sent just as it is to the wire mills, and is put through the ordinary processes of wire-drawing. The wire is therefore drawn without melting direct from the electro-deposited tubes, and the purity, as tested by Clark, Muirhead, and Co., is 104·48 per cent., over 4 per cent. above that of Matthiessen's standard of the purest copper hitherto attainable. In the hardest specimens the breaking stress is 29 tons, and the elongation only $\frac{3}{4}$ per cent. In the specimens produced to be of the softest quality the elongation is 35 per cent. Specimens were shown of bands of copper cut from the tube tied into a knot and drawn tight without sign of fracture. Another flat circlet from a tube was shown bent inside out and back again, with one part hammered together flat, without fracture. The tubes are deposited at the rate of $\frac{1}{8}$in. thick in 144 hours; this means, in practice, that orders for any size of tube of this thickness in quantities up to 100 tons can be manufactured within the week. The copper wire department is in the hands of a separate company, and it was stated that the whole output up to 200 tons a week is subscribed for by Birmingham firms in the wire trade.

ELECTRIC TRACTION.*

BY A. DICKENSON, A.M.I.C.E.,

General Manager to the South Staffordshire Tramway Co., and Consulting Engineer to the Birmingham Central Tramway Co.

I propose in dealing with this subject to avoid as far as possible technicalities, and to deal in a general and popular way with the question. I think it advisable here to refer briefly to the present position of tramways.

In the United Kingdom there are some 1,350 odd miles of tramway, to work which 27,060 horses, 539 steam-engines, and 3,645 cars are used, and there has been expended upon this and its equipment over 13½ millions of money, and for the year ended June 30, 1889, the surplus, after paying working expenses, amounted to some £713,543, equal, say, to a dividend of 5¼, and when we bear in mind that in very many instances, if due regard for depreciation had been considered, this profit would have been considerably reduced. It cannot, therefore, be denied that, speaking generally, the end for which tramways were constructed, so far as the shareholders are concerned, has not been all that could be reasonably desired.

It is no news to tramway men to say that the result of this somewhat unsatisfactory state of things is due in a great measure, if not entirely, to the excessive cost of the heretofore known methods of traction, and as regards steam tramways the various companies are only now beginning to feel its extreme costliness, but for the moment, apart from the question of cost, I know of no system in this country that is giving satisfaction to all parties.

Firstly, we have the horses, with their enormous depreciation, cost of feeding when not in use, risk of epidemic, complaints as to cruelty to animals, and, what is most serious to the travelling public, the very slow rate of speed at which they travel. Secondly, we have the steam-engine, with its complications and the restrictions placed upon it by the Board of Trade, and the frequent complaints by the public as to the objectionable fumes, smoke, steam, and excessive noise. Thirdly, we have the cable system, with its costly permanent way and its liability to breakages and other causes which suspend the whole of the traffic. Then, experimentally we have had ammoniacal and compressed air engines, which have not proved even so good as any of the before-mentioned. I therefore think that you will agree that most of the objections raised to the foregoing systems will be met and overcome by some form of electric propulsion.

As will be known to you, there are various systems of electric traction—there is the overhead conductor, the underground conductor, and the accumulator, or self-contained car. In each system the various manufacturers and others interested claim special advantages for their several methods. These advantages and disadvantages I do not now propose to discuss, but I venture to believe that you will agree with me when I say that the overhead conductor seems the most seductive, and if the prejudices of the various local authorities could be overcome in districts where the streets are suitable, no doubt it would be found to work quite as satisfactorily in this country as in America, where the streets seem specially adapted, and where a very considerable number of cars are operated upon this system.

I may here mention that some 10,000 h.p. is at work daily in America generating electric current, which is applied in some form to the driving of over 1,000 tramway cars. This, you will agree, conclusively proves that the experimental stage has been passed; and if we are precluded by circumstances from using a direct-current system we ought not to stand still, because we have the accumulator or self-contained car, which will not only meet all our requirements, but work more cheaply than either horse, steam or cable. Cars upon this system have been at work for a considerable time and have run a large number of miles upon the North Metropolitan tramways, at Barking, under contract at 4½d. per mile run, and we are told upon reliable authority that the actual cost has been less than this sum, the contract yielding a small profit to the Traction Company.

I find, taking three of the largest horse tramways in this country—viz., the North Metropolitan, the Glasgow, and the Liverpool United Tramway Companies—that their average cost of haulage, without allowance for depreciation, amounts to fully 6½d. per mile run; and for the three principal steam tramways—viz., the Birmingham Central, the Manchester, Bury, and Rochdale, and the South Staffordshire Tramway Companies—the average cost per mile run amounts to 5¾d.; or strike an average of the whole of the tramways in the United Kingdom (steam, horse, and cable), and say the total cost of haulage is 6d. per mile run, and let the cost of working the electric car exceed by ½d. per mile the figures given. Then, if the whole of the tramways in the United Kingdom were worked by the self-contained electric car, there would be a reduction of close upon £200,000 per annum in working expenses. Seeing that the self-contained car appears to be the electric car of the immediate future, we will proceed, with your permission, to give a few facts in connection therewith, giving instances only which have come under our own personal observation.

In November, 1888, there was tried upon the Birmingham Central Tramway a self-contained electric motor, which was designed upon the Julien system, by Mr. Thomas Parker, of the then Messrs. Elwell-Parker, Limited, and myself. The directors of the Birmingham Central Tramways Company permitted the experiments to be conducted upon their lines, upon conditions that the electric motor to be used should be in the form of an engine, insisting that before they would consider the question of electricity at all in connection with their lines, they must be convinced by actual demonstration that the power was as great, if not in excess of their most powerful steam-engines then in use; and when I point out that they are some 12½ tons in weight, having cylinders 9in. in diameter, and carrying a pressure of 175lb. to the square inch, you will agree that it was no small task to attempt. However, upon actual trial, the electric motor, although weighing only 9 tons or some 3½ tons less than their steam-engine, when coupled to one of them the electric engine hauled the steam-engine, in spite of the fact that steam was full on and pulling against the electric motor. We afterwards started, and hauled with the electric motor a load of some 30 tons up a grade of 1 in 32. We have also run with one charge of the accumulators 70 miles, hauling a car which, together with the load contained therein, weighed over six tons, and this on the heaviest grade of tramway worked by steam locomotives in Birmingham, travelling up a grade of 1 in 19 for over 500 yards in length during the day 10 times.

These and other trials so far satisfied the directors that they consented to the construction, and permitted the trial of a self-contained accumulator car upon their system, which was designed and built by the before-mentioned persons and firms. This electric car has been so successfully run over their heaviest steam route, and has given such satisfaction to the directors, that they gave an order for 12 electric cars, and they have just completed what is undoubtedly the finest installation of its kind in the world. This self-contained electric car has been run for and inspected by some of the most eminent engineers and electricians in the world, amongst whom I may mention Sir John Fowler, Mr. Preece, Sir Henry Mance, and Sir John Pender, all of whom expressed themselves as highly pleased.

The following particulars and brief description of the car, together with the drawing exhibited, will, I hope, be sufficient illustration for you to readily understand. The car is made to run upon a 3ft. 6in. gauge of tramways, and is constructed to carry 50 passengers, 24 inside and 26 outside. It measures, over all, in length 26ft., and in breadth 6ft. 3in., and from floor to roof 6ft. 6in. The kinds of wood used in its construction are oak, teak, pitch pine, and bird's-eye maple. The sole or foundation of the car body is made of channel iron, strutted so as to give it great strength and rigidity. The car body is carried upon two bogies of the ordinary kind. The motor is geared to the axles of one bogie by a train of helical gearing. Both the motor and the gearing are carried upon a specially constructed frame, which is so arranged that the pitch line of the teeth always remains constant. The bearings throughout are fitted with Richards patent plastic anti-friction metal, which reduces

* Paper read before the Tramways Institute.

the friction to a minimum and makes all the parts renewable. The accumulators are placed in trays (each tray contains eight cells), and these are carried under the seats of the car, the outer panels of which slide up behind the seats, so as to admit of their being readily placed in position. The connections are so arranged that contact is made automatically as the trays are pushed into position, the whole forming four batteries. The switches are of the Julien type, and are fixed so that the car can be driven from either end. They are so constructed that the cells can be equalised and the batteries used either in parallel or series. The brakes are specially designed and are of great power. The car, motor, and batteries weigh nine tons, as against the steam-engine and car 16½ tons, or a saving in the dead load to be hauled of 7½ tons. The space occupied in the street by this electric car is 26ft., or about half the distance of a steam-engine and car. Each car is supplied with two sets of accumulators, one set being charged whilst the other is doing work upon the road.

In the installation that the Birmingham Central Tramways have had fitted up, the labour in handling the accumulators in the shed is reduced to a minimum by having a specially-arranged balanced lift, and not only is the labour in handling reduced to its lowest point, but the storage room required for the accumulators is also in the least possible space.

This takes the form of a series of shelves upon the tops of hydraulic rams, arranged one above another, and extending the length of the car on either side of the track. These are so designed that they work in pairs, one balancing the other, and their positions are that one is right up whilst the other is down; or, say, the top shelf is about to be used on the right-hand one, the bottom shelf of the left-hand one is in the same position as regards the car, and the fact of bringing the second shelf of the left-hand one into position also places the corresponding shelf on the right-hand one into position also; or, in other words, although there will be 15 tons upon each ram the power required to place them will be considerably less than if each set had to be lifted separately, for we all know that if we have, say, 10lb. on each side of a pair of scales that the smallest fraction of a pound placed on one side will destroy the balance and cause one side to go up and the other down: this is simply what is done with these series of shelves. Each shelf is fitted with automatic connections, and is in every respect an exact duplicate of the car, so that when the accumulator trays are drawn thereon automatic connection is made, and the cells are charged whilst in position upon the ram without again being moved.

You will, I am sure, agree that it is most desirable, in the interests of tramways generally, that some more suitable motor than steam should be found, and I also feel sure that most of you are convinced that it has been found in the electric motor, and it is almost unnecessary for me to point out that an electric car has many advantages that cannot belong to the steam-engine.

What a boon to steam tramway managers and engineers to have all the advantages of the steam-engine without the smoke, steam, stench, and the non-liability to boiler explosions, the blowing out of a joint, and the consequent litigation arising out of having frightened someone's horse thereby. It seems almost too good to be true that it is possible to have the power on board of your vehicle, and not to be liable to be hampered as you are when using steam, and not to receive daily complaints from the residents along the line of route that their bedrooms are filled with sulphur, or that you have spoiled a pair of curtains, or thousands of other things that none but one of the unfortunate gentlemen connected with steam tramways know of.

To the horse tramway companies the electric car has more advantages than even to the steam tramway companies. You scarcely speak to a horse tramway manager about his receipts per mile run but that he begins to complain that it is most unfair to make comparisons. "How can you expect," says he, "that we should carry as many passengers as a steam car; horses cannot do it." "No, but electricity can, and that, too, cheaper than your horses." Within reasonable limits, you can make the carrying capacity of your electric car what you like, and, what may be of considerable importance to horse tramways, the electric car can not only be driven by the horse-car drivers, but run in the same service with horse cars if desired.

I have refrained in this paper from dealing with the subject from a scientific aspect, preferring rather to leave that side of the subject to the more expert electrician; but as a practical tramway manager and engineer I do not hesitate to state that I am thoroughly convinced that horse, steam locomotive, and cable will in a few years hold a very different position than they now do in tramway haulage.

THE EDINBURGH EXHIBITION.—X.

At stand No. 108, Mr. James Pitkin, electrical and philosophical instrument maker, of 56, Red Lion-street, Clerkenwell, exhibits electric chronographs, firing keys, reflecting galvanometers, electrical measuring instruments, electrical hand lamps, hydrometers, gas detectors, etc.

Capt. Holden's Improved Electric Chronograph.—The type of chronograph usually employed for the measurement of a very small interval of time or for the measurement of the velocity of projectiles fired from small arms, as well as the heaviest natures of ordnance, is that which is known as the "drop" type, signifying that the records are obtained on some registering surface falling under the influence of gravity. Screens of wire or some such equivalent devices which are cut by the projectile in its flight are employed when the velocity to be determined is that of a bullet from a rifle or a shot from a gun. The instrument under notice, of which Captain Bréger's instrument is the prototype, consists principally of a pillar supporting two electromagnets, one at a higher point than the other, which in their turn serve to support two iron-tipped rods. The longer of these two is suspended by the magnet, which is in the circuit through the nearest screen to the gun, and which consequently is the first to fall. When a shot is fired this rod is covered with a copper tube, on which the records are made by the recording knife. The shorter rod falls on to a table connected with a trigger, which releases a spring carrying a knife, by which the longer rod is marked in its falls.

Before taking a reading both circuits are closed, and the rods suspended by their respective magnets, then by means of an accessory instrument called a "disjunctor." Both the circuits are broken absolutely simultaneously, and thus the loss of time occasioned by the non-instantaneous release of the rods by their respective magnets on the circuits being broken, as well as the delay in the action of the trigger on the knife, is mechanically determined with great exactness. This having been done, and the rods again suspended, the gun is fired, and the screens being broken the rods fall one after the other, and the mark is made this time at a higher point on the rod, corresponding to the time that the projectile took to pass from one screen to the other. The distance between the mark thus made and the former one gives us the means of ascertaining the velocity of the projectile. For if the distance between the screens be known, also the force of gravity at the spot, together with the mass of the falling body, its acceleration is then known, and by adjusting the instrument, which can readily be done, so that the mark made when the disjunctor is used is always the same height on the rod, we can apply a micrometer scale to measure directly the velocity of the projectile at the middle point between the two screens, when these latter are always the same distance apart.

The chronograph, as shown, was designed by Capt. C. Holden, R.A., of Woolwich Arsenal. All the electrical and mechanical parts have been carefully thought out, so as to eliminate, as far as possible, all errors due to residual magnetism, mechanical friction, and instability. To this end the iron cores of the magnets are specially designed; the number of turns and the resistance of the wire in each coil is made quite uniform. To eliminate "Foucault" currents the German silver bobbins are split. On each coil a visual indicator has been added to show when the current is passing through the coils, and also to detect leakages. To prevent friction all the bearings are jewelled, and greater accuracy in the readings is obtained by adding

a sliding index to the vernier scale. Instead of movable knife-edges, each instrument is now provided with levels, so that when the chronograph is once set up it can easily be verified and readjusted. An entirely novel feature in the improved instrument is the introduction of a switchboard. On this board are placed two circular variable resistances (used for regulating the current through the electromagnets, which are then placed in exactly similar conditions, both electrically and magnetically), an instantaneous electrically worked disjunctor, which does not require recocking and which can readily be adjusted to any requisite speed of break, a mercurial reversing switch, and a disjunctor key. In the older form of chronographs the disjunctor was always a continual source of trouble and annoyance, as well as error. The new disjunctor has got over these difficulties entirely. The mercurial reversing switch is a most important addition, as by its means the correct working of the disjunctor, on which the instrument entirely depends, can instantly be verified, and it also serves to disconnect the batteries and lines from the instrument when it is not in use. All the connections are carried up to stout brass terminals placed at

Fig. 1.

the top of the board, so that to join up the batteries, line, and instrument to their respective terminals is an easy matter, and any portion can be tested without disturbing other parts. All the working parts, contacts, etc., are thoroughly protected from dirt and accidental damage. Instead of the clumsy and inaccurate method of scratching the place where the disjunctor mark should be, on the fall tube by means of the knife-edge, a special instrument is now supplied for this purpose. The batteries used for working the whole system are of the secondary type. This class of battery has now been in successful operation for working the above instruments for several years. The "Holden" chronographs are now in use at all the principal Government factories, not only in England, but in India and elsewhere.

Among the other instruments devised by Captain Holden and shown on this stand are a firing key and firing battery combined, a locking and short-circuiting key, an improved wire chronograph screen, an improved reflecting galvanometer, and a new form of hydrometer.

The combined firing key and battery is a safety device now in use for firing large ordnance. The safety arrangement serves the double purpose of testing as well as automatically locking the firing key until such times as the circuit through the fuse is completed. A visual indicator and telltale is also placed above the push. By means of this it is possible to detect any faults in the connections, lines, or tubes at the time of firing.

The "Holden" hydrometer is a useful piece of apparatus which seems to have been overlooked by users of secondary batteries. Fig. 1 illustrates the method of using this hydrometer in an accumulator cell. The hydrometer float consists of a cylindrical glass bulb, about 3in. long, terminating in a thin glass rod between 8in. and 9in. in length. Owing

Fig. 2.

to the great difference between the amount of displacement relatively of the bulb and stem, the instrument can be made of a very open range. A difference of 7in. may readily be obtained in an alteration of density of, say, from 1,150 to 1,200. A separate vulcanite scale is used. The scale is fastened to a lug or connector of the battery element by means of an indiarubber band. The scale is so adjusted that its point just touches the surface of the liquid. The float is free to move up and down in front of the fixed scale. The reading is taken from the top of the pointer. These instruments are shown in several sizes, and of various ranges. They may be made either in glass or vulcanite. They are extremely accurate, easily visible, and do not stick to the side of the cell.

Fig. 3.

The Holden-D'Arsonval reflecting galvanometer is shown in Figs. 2 and 3. It is a development of the well-known D'Arsonval zero galvanometer. Those familiar with the earliest form of Sir William Thomson's syphon recorder will at once be able to trace the evolution from the recorder to D'Arsonval's instrument. Take away the glass syphon recording arrangement and replace it by a small mirror which can be fixed to the coil, and the transformation is complete. In the improved instrument we have a powerful laminated permanent magnet of circular form placed horizontally. The poles having been brought

round to face each other, are turned out so as to encompass the moving coil. In the centre of the magnetic field and midway between the poles a cylindrical rod of soft iron is held. This mass of soft iron serves to concentrate the lines of force and to make the magnetic field uniform. The moving coil is built up upon a very light silver frame. The current is led into the coil by means of a platinoid wire, starting from a spring at the top of the instrument. The current then passes through the coil, and out at another platinoid wire fixed at the bottom and attached to a mill-headed screw. There is a spring at the top to give the necessary tension. The mill-headed screw is used to produce the desired torsion in the suspending wires to bring the mirror to its zero. A special point about the galvanometer is the arrangement for lifting out the coil system and its soft iron core, and the method employed for readily renewing the suspension wires. By unscrewing a clamping screw and removing one connecting wire from a binding screw the whole coil system comes out. The advantage of this is apparent. It greatly facilitates the mounting and adjustment of the coil, mirror, etc., and at the same time reduces the chances of damage in transit. The instrument can be fitted with several coils of different resistance, which can be instantly removed, and substituted the one for the other. With a resistance in the coil of 16 ohms, and an added resistance of 100,000 ohms, a deflection of the coil equal to an angle of 1deg. may be obtained with a pressure of one volt. By suitable shunts and winding the instrument may be made into a very good milliampere-meter or voltmeter. The scale is found to be of practically equal divisions. Care seems to have been taken to reduce everything to its simplest form. The essential parts are carefully made, and on the non-essentials no labour has been wasted.

Fig. 4.

A simple form of ampere-gauge is also shown (Fig. 4). In this instrument there is a small coil suitably wound on a metal bobbin. Inside the bobbin is fixed a segment of soft iron. A bar of soft iron attached to the end of a pointer, whose bearings work in jewelled holes, is free to move in the same plane as the fixed segment. When the current is running through the coil, both the fixed and movable iron masses assume the same polarity. Repulsion, therefore, takes place. It is found that within certain limits the scale readings are nearly uniform. The most useful range is said to be between 1 and 20. Instruments measuring from ·1 to 2 amperes, and from 2 to 40 amperes, are now made. Each ammeter is separately calibrated from a standard instrument. In appearance they are very neat, and as the price is low they should have a ready sale.

An assortment of Pitkin's portable batteries and lamps are shown. These goods are now so well known that they need no description here. We have the 2, 3, and 4-cell batteries fitted up as miners', travelling, and pocket lamps; secondary batteries for medical and many other purposes. Some of the lanterns are fitted with plain plate glass fronts, others with bull's-eye lenses. One of the lanterns is fitted with a detachable ruby glass front, which is said to be useful for photographic purposes.

A novel and very neat-looking portable primary battery and lantern is also shown. This battery is constructed to run for a period of 10 hours with one charge of the solution. It is a zinc-carbon battery of the single-fluid type. The elements are automatically withdrawn from the solution when the burner is not in use. As no action goes on when the elements are out of the solution, one charge may be spread over a period of many months when the light is only required for occasional and short periods. The above lamp has been devised for use where a dynamo is not available for charging secondary batteries.

There are also on show several of Pitkin and Niblett's explosive gas detectors. There is a large inspectional instrument, having a bold and open scale, a handy pocket instrument in a leather case, made especially for the use of those engaged in coal gas works, etc.; and also a small metallic detector about the size of an ordinary pocket aneroid barometer. Acting on the experience gained during the past year, substantial improvements and alterations are now being made in these instruments. Nearly all the defects and weak points brought out by actual practice have been remedied. The detectors can now be made so sensitive that they will detect $\frac{1}{10}$th per cent. of coal gas when mixed with air.

Although these instruments have little or no connection with electrical matters, yet they might be found to be of great service to those engaged in running underground cables. Coal gas frequently leaks into the conduits into which electric light mains are now being run. If a spirit flame or other light is brought near, an explosion is usually the result. Lately, several serious accidents of this nature have occurred. These instruments will readily detect and localise leaks of coal gas, even if in the most inaccessible places. In addition to the visual arrangement, they may be made to give a record on paper, or to give an alarm by completing an electric circuit through a bell or other telltale. Quite a number of these detectors seem to have been sold, many orders coming from abroad, especially from France, Belgium, and Italy, where they seem to be much appreciated.

A FLEXIBLE CONDUIT SYSTEM.

An ingenious attempt to combine the advantages of the direct current transmission with the conduit system for electric tramcars without having an open slot, and at the same time without complicated connecting mechanism, has been made in America by Mr. W. J. Cordley, and is shown in the accompanying cut. The principle employed is a main conductor enclosed in a small conduit of flexible material run, as shown, close to the track. The working conductor closes the flexible conduit at the top and is normally unconnected with the main feed-wire. When, however, the contact wheels on the car press upon the working conductor, it is forced downwards into contact with the feed-wire, and a continuous supply of electricity is furnished to the car. As in other conduit systems, it is not safe to make predictions as to the advantages or disadvantages that will probably be found in this system. A rubber insulation is, of course, liable to deterioration, and other difficulties may be found to be inherent in the plan of a

Conduit with Flexible Walls.

conduit with flexible walls. Nevertheless, the idea of a working conductor normally out of contact with the feed-wire, and pressed into contact only when desired, is an excellent one, and unless on experiment the mechanical difficulties of arranging it should prove to be too formidable, we may make its acquaintance in actual use on the streets. Devices of this kind have very marked advantages over the slot conduit, and whoever successfully avoids the difficulties that have stood in the way heretofore will make a valuable addition to our present means of urban electric traction.

THE

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

EMBRYO COMPANIES.

"The horns of a dilemma" is an expression frequently heard, but less frequently appreciated. Most people if asked to explain it would do so by stating the person in this position to be in a warm corner, out of which he could not emerge without considerable scorching. If anyone is ever upon "the horns of a dilemma" it is the technical journalist in his relations with embryo companies. Whatever course he takes he falls foul either of one party or of another, and is anathematised accordingly. If he works for the benefit of the public by suggestions based upon "proof prospectuses," which are usually submitted to him as "private and confidential" documents, the public know nothing of his efforts, and for whatever he may save them he gets no thanks from them, while he is certain of anathemas from the promoters. If, on the other hand, he criticises publicly the prospectus submitted to him, he is guilty of a breach of trust, and may find that the final prospectus is altogether different to the "proof." Breach of trust, however, nowadays seems of very little importance in this connection, and is more honoured in the breaking than in the keeping. *Pro bono publico* is the excuse for this laxity of morals, and as it is customary to follow the lead of Romans in Rome, we intend in this article to refer to "embryo companies"—that is, to companies whose prospectuses are not issued to the public, but only to certain interested parties, and are "subject to revision."

The technical journalist has frequently good grounds for wishing to have his say upon a company's prospectus, but is generally left without the opportunity unless he takes the bull by the horns and comments upon the private document, for promoters of companies are keen enough to come before the public after the technical papers are printed, and before the next issue the lists are closed. This sharp practice on the one hand partially accounts for the sharp practice on the other. In certain recent cases definite promises have been made that the technical press should have an opportunity of dealing with the subject when the time was ripe for bringing out the companies, and considerable alterations have been made in the provisional prospectuses in deference to the views privately expressed upon them.

In discussing company promotion, we have to consider first if the industry can well proceed without the formation of large companies, and the answer to such a question is in the negative. Assume, then, that companies are a necessity, how are they to be formed? Naturally, the people who initiate the matter look first to their own pockets. If they can lay hold of a good thing to bring before the public they prefer to do so, because their gain will be greater and more certain than with doubtful concerns.

Those who have had much to do with the floating of companies know that the figures in a prospectus are always more or less misleading. If an amount is paid as purchase money this amount usually includes, not only the cost of purchase, but the preliminary expenses, the profits of the promoters, and the cost of underwriting. It is a mistake to think that success is left to the chance applications of the public as induced by advertisement. Not so; a large part of the capital is underwritten. If the public apply, so much the better for the underwriters. If, on the contrary, the issue is somewhat of a "frost," the underwriters have for the time to suffer, and engineer the company to a quotation that will pay, and then quietly unload. The real purchase money is seldom more than a quarter the amount appearing in the prospectus, and of course the important question is whether the promoters do not reap too large a benefit. We think they do. On the contrary, they maintain they do not. The risks are large, the expenses are also large, and in the majority of cases the recompense is not great. Occasionally it is admitted a gigantic haul is made, but these are the prizes of the promoting profession. The worst feature of company promotion at the present day is to be found in "founders' shares," a system that has only recently come into general use.

In considering the position of an embryo company, all these and many other things have to be weighed. The prospects of success are generally presented in a very flattering manner. The old-fashioned five per cent. return is not in it in these days when two, three, or four times that return is delicately hinted at, if not absolutely promised. We have lately read an adverse criticism upon an embryo company, whose proof prospectus has been altered again and again—each time very largely to the benefit of the intended future shareholders. The board is an exceedingly strong one, and its work is connected with electric traction. We will assume the criticism to be justified, as founded upon the proof prospectus seen. The reply to the criticism is simple and effectual. It is that the critic has entirely missed the right sphere of the company's proposed labours. Certainly, a paragraph in one of the prospectuses may be read in a particular way, but that paragraph is said to refer to incidental work only, and arguments detrimental to the company founded upon it must be incorrect. The great work proposed by the company is in another direction entirely. Let us explain more clearly. Suppose the adverse criticism is founded upon the view that the principal work was to provide electric traction for existing tram lines, when the company's work is really to be the initiation and construction of, and haulage upon, new lines. The difference in the character of this work is so great that similar arguments cannot apply. Indiscriminate harrying of promoters is as likely to do as much harm as a general and unreasoning agreement with them. Much better work both for the industry and for the public can be done by privately suggesting, at any rate until it is found that the promoters will not listen to such suggestions.

THE BOARD OF TRADE.

The actions of the Board of Trade form subjects for consideration by all supply companies—in fact, by all electrical engineers—and not always of a pleasing character. When the Birkenhead Provisional Order was under discussion last week, a clause, or rather a section of a clause, was agreed to which will undoubtedly have to be altered, although it is understood that the clause will be followed by the Board of Trade in all other orders. The third sub-section of clause 6 now reads as follows:

"The undertakers shall construct their mains and other works of all descriptions, and shall work their undertakings in all respects, so as not injuriously to affect the working of any existing electric circuits from time to time used or intended to be used for the purpose of telegraphic, telephonic, or electric signalling communication, or the currents in such circuits, and shall use every reasonable means, in the construction of their mains and other works of all descriptions and the working of their undertaking, to prevent injurious affection, whether by induction or otherwise, of any electric circuits used or intended to be used for the purposes aforesaid, whether existing at the time of the construction of such mains or other works or not, or the currents of such circuits."

Can any business man uninterested in electrical matters agree that the embargo laid on electric light and power engineers is just, which reads "whether existing at the time of the construction of such mains or other works *or not*"—that is, the engineer is to provide not only for past and present, but also for future telegraphic or telephone wires. This is preposterous.

COST OF ELECTRIC LIGHT.

Circumstances alter cases; that is admitted, but many English firms have business outside England, and, where circumstances may approximate to the cases referred to, in America. Till the various central stations in England have been running for some years, no real knowledge as to actual cost will be available. In the early years the expenses are great in proportion to the income, and this holds till the station is running in its normal condition with full loads. When a place is supplied with electric light at a fixed charge we, of course, know the cost

to the purchasers, but for practical men this knowledge is almost useless. Hence, even in America, Table II., given below, will be more interesting than Table I. Kansas City has been investigating the cost of artificial lighting, and the report gives a number of tables, among others the following:

TABLE I.—Electric Light as Supplied by Private Companies.

Name of city.	Schedule.	Number of lights.	Cost per night.	Candle-power.
			Cents.	
Kansas City	All night ...	114	55	2,000
Atlanta, Ga.	All night ...	596	53½	2,000
Baltimore, Md.......	All night ...	607	40	2,000
Binghampton, N.Y.	All night ...	123	36	2,000
Birmingham, Ala.	All night ...	100	33	2,000
Buffalo, N.Y..........	All night ...	1,296	40	2,000
Cleveland, O...... ...	All night ..	100	38	2,000
Denver, Col.	All night ...	216	53	2,000
Duluth, Minn.	All night ...	186	35	2,000
Jackson, Mich..	All night ...	210	24	2,000
Lowell, Mass.	All night ...	180	50	2,000
Memphis, Tenn. ...	All night ...	100	50	2,000
New Bedford, Mass.	All night ...	90	40	2,000
New Haven, Conn.	All night ...	—	48	2,000
Richmond, Va.......	All night ...	134	40	1,200
St. Louis, Mo.	All night ...	1,587	20½	2,000
Sedalia, Mo.	Moonlight ..	91	24¼	2,000
Springfield, Ill.......	Moonlight ..	110	38¾	2,000
Troy, N.Y.............	All night ..	279	39½	2,000
Wichita, Kan.	All night ..	90	30	2,000

The committee call attention to the peculiarity that the smaller cities and towns using fewer lights are supplied at cheaper rates than cities with many lights; they think that if this condition is financially sound electric lighting is an exceptional business. We suspect that all the facts being known it would be found that some of the smaller companies are taking business at unremunerative prices. The cost of the electric light to cities owning their own plant is herein given.

TABLE II.

Name of city.	Number of lamps.	Candle-power.	Cost of each light per night.
			Cents.
Bay City, Mich..............	134	2,000	16⅔
Bloomington, Ill............	220	2,000	20
Chicago, Ill.	520	2,000	19
Hannibal, Mo.	96	2,000	14⅓
Lewiston, Me.	96	2,000	11⅔
Little Rock, Ark......	110	2,000	13⅓
Madison, Ind.	85	2,000	13½
St. Joseph, Mo.............	208	2,000	14⅓
Topeka, Kan................	184	2,000	18

Result: The committee suggest that an electric lighting plant be put into the new City Hall, to supply that building and the adjacent streets.

TRAMWAYS.

The paper of Mr. Dickenson, which we give elsewhere, is one of the first on the subject of electrical traction that has been read and discussed in this country by practical men. Outsiders too frequently think they know all about tramway work, but their views are often in opposition to those whose daily work is upon tramways. We may now take it that the average cost per mile run of haulage upon tramways is 6d. Mr. Dickenson talks about what he knows, and describes what has been done rather than what is estimated as being possible. One or two references in his paper were handled adversely in the discussion, especially the statement that the Barking contract showed a profit at 4½d. per mile. From certain information which we have received, we incline to the opinion that the profit obtained is solely calculated upon immediate takings and outgoings, without considering depreciation, as was suggested in the discussion. Before any money is available for dividend, allowances must be made for depreciation unless all apparatus is kept in a state of the highest efficiency out of income. It will take some time to obtain absolutely trustworthy figures, and the thanks of everyone engaged in electrical work must be given to Mr. Dickenson, whose paper has led to the promise of Mr. Smith to provide such figures at the next meeting of the Institute, to be obtained from the working at Birmingham. Mr. Dickenson's conclusion that self-contained cars will be largely adopted on all old lines, if it can be proved that the cost is no greater than with the systems now in vogue, should lead makers to pay special attention to accumulator work, and so modify their construction as to make them more suitable for such work.

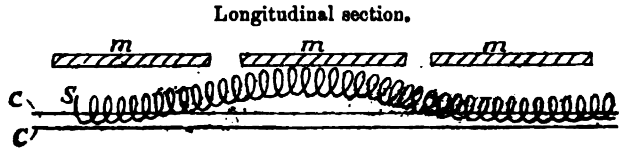
CORRESPONDENCE.

THE LINEFF TRAMWAY SYSTEM.

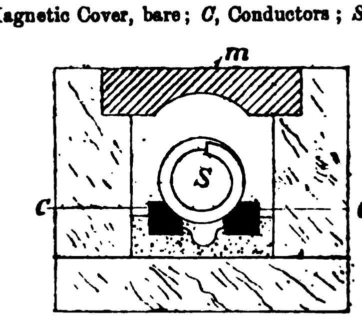
TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—The method of working tramways by electricity described in your paper of the 4th inst. goes in my office under the name of "the snake trick," because I found, when experimenting in the same direction in 1886, that the employment of a flat strip presented many practical difficulties which, if not already discovered by Mr. Lineff, will make themselves apparent in time, and most of these objections were obviated by the employment of a spiral wire coil which could wave and twist as required—hence the name "snake."

Longitudinal section.



m, Magnetic Cover, bare; C, Conductors; S, "Snake."



Cross section.

I have not yet published the details by which I met the difficulty of dealing with points and crossings, where it is obvious there is immediate danger of a short circuit. I am therefore curious to know what Mr. Lineff's method will be.

being of a steel-grey colour, a band of blue metal appearing on the upper portion of the plate, near the water-line.

20. *Borate of Antimony.*—A hot solution of boracic acid was first prepared, in which was immersed an antimony anode and a brass cathode, the current from two cells being used. In a few minutes after the electrodes were immersed, a film of antimony appeared upon the negative plate, showing that the acid had exerted solvent action upon the antimony under the influence of the current.

21. *Antimoniate of Potassa.*—A quantity of antimonic acid was first prepared, to which was added a solution of caustic potash, and the mixture heated for a few minutes, after which it was set aside to cool, and the clear liquid was then decanted for use. With the current from one cell a film of antimony of fairly good colour soon formed upon a brass plate; the proportion of the antimony acid which had entered into the liquid was not sufficient, however, to render the solution of any practical interest.

22. *Oxalate of Antimony by Electrolysis.*—A strong warm solution of oxalic acid was first prepared, and this was electrolysed with the current from three cells. After a few minutes' immersion of the electrodes an iridescent film of antimony formed upon the brass cathode. Very little hydrogen was evolved, the bubbles of which remained stationary upon the plate. On rubbing the film with the finger there was evidence of the presence of metallic antimony, but the acid appeared to have but a trifling solvent action on the anode.

23. *Nitrate Antimony by Electrolysis.*—A solution of nitric acid was first formed by mixing one part by measure of nitric acid with nine volumes of water, in which was placed an antimony anode and a brass cathode. The current from two cells was used, and after a few minutes a grey powder was found to have deposited upon the anode, which gradually accumulated and, falling off the plate, deposited at the bottom of the vessel. At the same time a slight film of antimony appeared upon the brass plate. The results from this solution were not, however, of a satisfactory nature.

24. *Electrolytic Crystals of Antimony.*—Having a desire to obtain, if possible, metallic crystals of antimony by electrolysis, in the same way as that in which I had obtained crystals of tin and lead recorded in former papers, I laid a plate of glass in a shallow dish, pouring into the vessel a sufficient quantity of a strong solution of terchloride of antimony to entirely cover the glass plate. An anode of antimony, connected to a couple of Daniell cells, was then placed at one end of the glass plate and resting upon it, while the end of the negative wire of the battery was placed at the opposite end of the plate, the respective electrodes being thus immersed in the terchloride solution to the depth of about $\frac{1}{16}$th of an inch. Under this arrangement the electrolytic action was allowed to proceed without interruption for about 48 hours, at the end of which period a crop of crystals was found to have formed upon the glass plate, extending from the point of the negative wire to about 2in. beyond in the direction of the anode. The crystals, which were about $\frac{1}{32}$nd of an inch in thickness, assumed a coral like form, and were exceedingly brilliant. They were, however, very brittle, and it required some care to remove them from the plate, although the metal presented a very solid appearance. Further attempts were made in this direction with a view to obtain crystals which could be employed as negatives for obtaining photographic prints, as I had done in the case of lead and tin crystals, but the metal invariably deposited in too solid a form for the purpose.

25. *Sulphates of Antimony and Ammonium.*—To form a bath, moderately-strong solutions of sulphate of antimony and sulphate of ammonia were mixed, and the liquid then electrolysed with the current from two Daniells, when a deposit of antimony soon formed upon a brass plate. After a short immersion, however, the film assumed a dark colour, when it was deemed advisable to remove a considerable portion of the anode from the solution, when the deposition proceeded more favourably. The anode, however, appeared to be somewhat slowly attacked during the electrolysis, rendering the solution an unfavourable one for the deposition of the metal for practical purposes.

26. *Antimony in Bisulphate of Potassa by Electrolysis.*—A solution of bisulphate of potassa was first prepared, in which was placed an antimony anode and a brass cathode, and the current from three cells allowed to pass through the liquid, when in the course of a few minutes a film of antimony deposited upon the cathode, the metal adhering firmly to the brass surface.

27. *Terchloride of Antimony by Electrolysis.*—An electrolyte was prepared by mixing two parts of hydrochloric acid and one part nitric acid, with nine parts of water, by measure. In this solution was placed an antimony anode and a brass cathode as before, and the current from three Daniells was then allowed to pass through the liquid, when in a few minutes after a bright film of antimony formed upon the brass plate. Shortly after, however, a brown non-reguline deposit formed on the surface of the reguline film, which was easily wiped off with the finger; at the same time, a white deposit of oxide was found to have settled at the bottom of the vessel, which did not appear to redissolve in the liquid.

(To be continued.)

ALTERNATING-CURRENT MOTOR.

The accompanying cut illustrates diagrammatically an alternating-current motor, recently patented by Elihu Thomson, of Lynn, Mass. Rotation in this motor is due to the reaction between an alternating-current field and a locally short-circuited armature. This class of motors, when running at normal speed, is capable of sustaining speed in synchronism, or nearly in synchronism, with the alternations of the feeding-wire, but is incapable of starting.

The invention consists in commencing to run the motor with a different circuit arrangement for its armature from that which it will have under the condition of steady normal working. This primary condition is one adapted to give a torque. When up to speed the motor is run with the armature on continually-closed circuit.

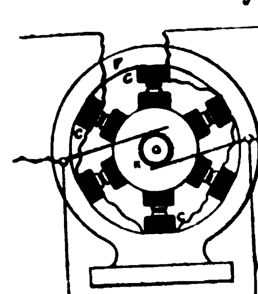


FIG. 1.

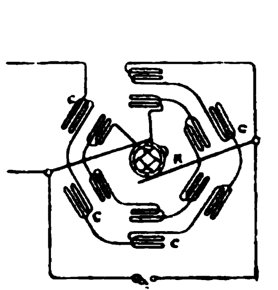


FIG. 2.

In the accompanying cuts, Fig. 1 is a side elevation of a form of motor to which the invention may be applied. Fig. 2 is a diagram of the circuits and connections of the apparatus. In the figures, F represents a laminated field-magnet frame having projections upon which are wound coils, C, as many as six in number. These projections extend inwardly toward a revolving laminated armature. Upon the shaft of the machine is a commutator, K, consisting of six segments, each alternate segment being connected so that there are in reality but two divisions of three segments, each fitted together. The armature coils are so connected that if a continuous current were passed through the coils the projections on the armature would assume alternately north and south polarities. The field coils are connected in a like manner. Now, if an alternating current be passed through the field coils, C, the motor will not start to rotate, whether its armature circuit be practically open, or whether the coils be on closed circuit; but it will continue to rotate in either direction if it is once started, if the armature coils are placed on closed circuit, and the current fed to the coils, C, has sufficient energy. In the motor shown, the alternating current which passes through the field is made at the start to circulate through the armature. In the initial condition of the motor the brushes are set backward or forward into proper posi

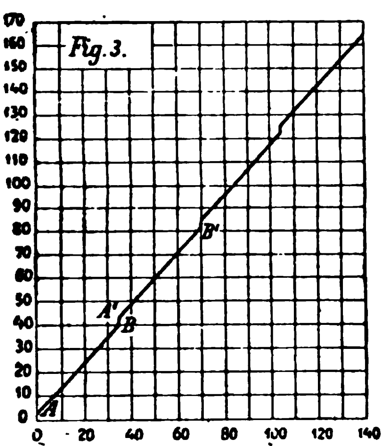
tion, where the armature will begin to rotate. When a certain speed has been obtained, the motor is made to assume its normal working condition and to continue its rotation without the commutator by short-circuiting the armature by any desired means. These changes of condition may be made by devices manually operated; but the inventor prefers to bring them about automatically by the operation of some device responsive to the change of speed of the armature.—*Western Electrician.*

THE IMPORTANCE OF ACCUMULATORS FOR THE ECONOMY OF CENTRAL STATIONS FOR ELECTRIC LIGHT.

BY DR. GUSTAV RASCH, AACHEN.

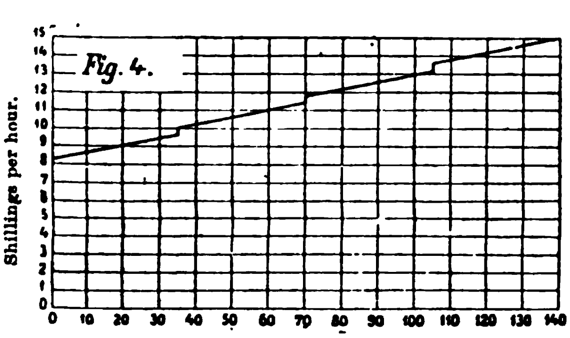
(Concluded from page 17.)

The curves 1 and 2 have their maximum at the point of zero ampere-hours capacity, and descend with increasing capacity, because the machinery becomes smaller and cheaper, and all the machines will work under more favourable loads. Curve 3 ascends with increasing capacity, and



Thousands of Watts.

if the calculations are based upon the price lists of Müller and Einbeck, exactly proportional with the capacity. By adding all these ordinates we obtain the curve of the working expenses (4). This curve firsts descends to a minimum, and afterwards slowly ascends. It is this minimum which gives us the economical capacity of the storage battery. We have not yet taken into consideration expenses which are independent from the motive power. We ought, for instance, to consider that a central station without accumulators requires a larger staff, but, on the other hand, an accumulator plant brings new expenses for apparatus which would not be necessary for pure machine plant, so that one saving is equalled by an additional expense.



Thousands of Watts.

It seemed to me very interesting to make a comparison between the running of a central station with and one without accumulators, and I have adopted as far as possible the suppositions of Herr Fritsche.

Suppose the case where the collecting copper bars at the central station require a maximum of 120 kilowatts, or 100 volts and 1,200 amperes—and this energy must be supplied if one machine fails by the others, together with not more than 15 per cent. overload—if there are accumulators in use the same terms exist for the machines with regard to their overloading, and the storage cells must not be discharged with more than their maximum current; the size of the machine plant is thus limited.

Let us assume four machines and a pure dynamo plant, three of them must give 120 kilowatts with 15 per cent. overloading; the normal output of one machine therefore is

$$\frac{120{,}000}{3 \times 1{\cdot}15} = 34{,}800 \text{ watts.}$$

With accumulators of an economical capacity = 1,100 ampere-hours and a maximum discharging current of 330 amperes, we may reduce the dynamo plant by the capacity of the accumulators, 33,000 watts; the normal output of one dynamo must be

$$\frac{120{,}000 - 33{,}000}{3 \times 1{\cdot}15} = 25{,}200 \text{ watts.}$$

Cost of Putting Down the Plant.

	Without accumulators.	With accumulators.
Buildings	£750	£750
Dynamos (4 at 35 kilowatts)	1,220	...
" (4 at 25·2 ")	...	880
Steam-engines (4 at 56 h.p.)	2,020	...
" (4 at 40 h.p.)	...	1,620
Boilers	2,160	1,735
Well and draining plant	1,000	1,000
Apparatus	335	500
Cables	17,450	17,450
Accumulators	...	1,100
	£24,935	£25,035

According to the suppositions made between depreciation and output of the machines and boilers the percentage of depreciation will be for

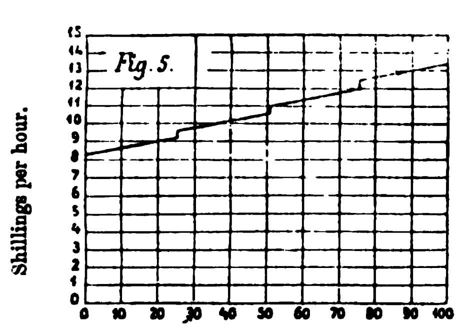
	Without accumulators.	With accumulators.
Dynamos and steam-engines	5·2 per cent.	5·9 per cent.
Boilers	9·6 per cent.	10·8 per cent.

and therefore the

Working Expenses

	Without accumulators.	With accumulators.
Interest, 4 per cent. on capital outlay—£24,935 or £25,035	£997 8 0	£1,001 8 0
Depreciation—		
Buildings, 2 per cent.	15 0 0	15 0 0
Wells, draining, 5 per cent.	50 0 0	50 0 0
Apparatus, 10 per cent.	33 10 0	50 0 0
Dynamos {5·2 per cent.	63 9 0	...
Dynamos {5·9 per cent.	..	51 18 0
Steam-engines {5·2 per cent.	105 1 0	...
Steam-engines {5·9 per cent.	.	95 12 0
Boilers {9·6 per cent.	207 7 0	..
Boilers {10·8 per cent.	...	187 8 0
Cables, 5 per cent.	872 10 0	872 10 0
Accumulators, 9 per cent.	...	99 0 0
Management	685 0 0	625 0 0
	£3,029 5 0	£3,047 16 0

Or, per hour without accumulator, 6s. 11d.; with accumulator, 7s. 1d.



Thousands of Watts.

In this total we have not yet included the expenses for coal, oil, cleaning and lubricating material, etc., which may be taken in accordance with the figures given by Herr Fritsche, except those for the efficiency of the machines, as this author assumes that these costs increase proportionally with the consumption of electrical energy, which is not correct for the consumption of coal. I know one dynamo of a very good system which is sold for an output of 11,500 watts and which requires 1,140 watts—that is, 10 per cent.

of its output—for running without load. We, therefore, may safely suppose that for the dynamos in our special case (25,200 and 35,000 kilowatts) the energy wasted in empty running is about 8 per cent. of the normal output; if the electrical efficiency is 92 per cent., the 35-kilowatt dynamo must receive a mechanical energy of

$$35{,}000 \times 0{\cdot}08 + \frac{35{,}000}{0{\cdot}92} = 2{,}800 + 1{\cdot}09 \times 35{,}000 =$$
$$2{,}800 + 1{\cdot}09 \times W,$$

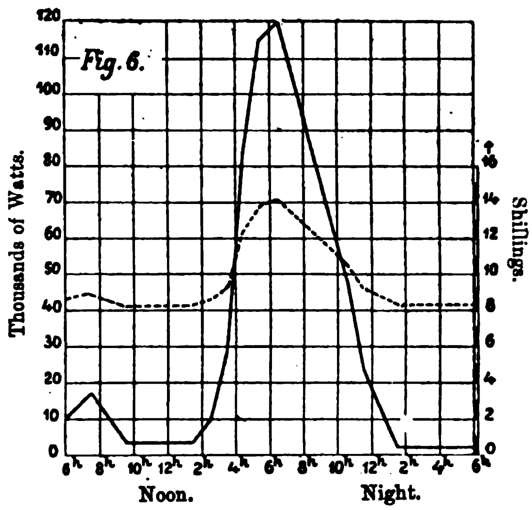
where W means the varying output, and which equation is given as a curve in Fig. 3 (W are the abscissæ, the mechanical energies are the ordinates).

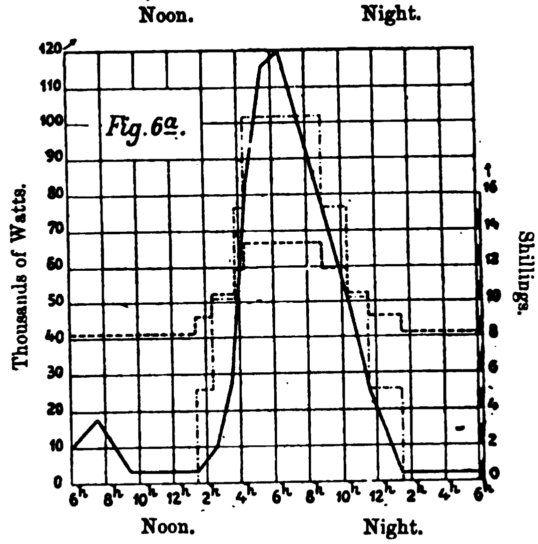
The point B shows the normal output (35 kilowatts), then a second dynamo is switched in; both machines working with half the load require, therefore, double the amount of mechanical energy for empty running,

$2 \times (2{,}800 + 17{,}500 \times 1{\cdot}09) = 43{,}800$ watts (point A');

if both machines are fully loaded they require

$2 \times (2{,}800 + 35{,}000 \times 1{\cdot}09) = 82{,}000$ watts (point B').

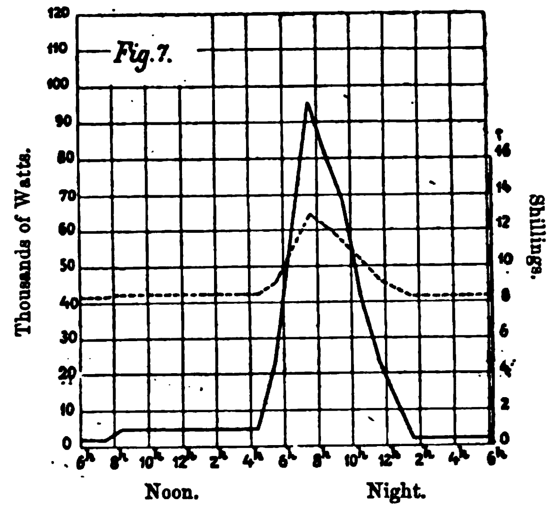


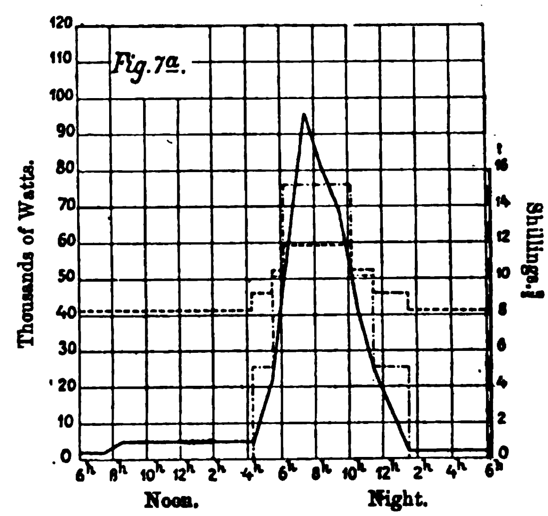


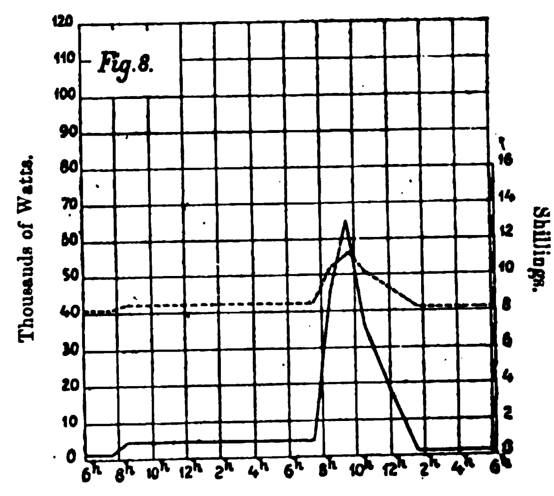
With each machine additionally switched in, the curve shows a jump, according to the amount of the empty running for one machine; this is still more to be considered as the supposition of the 8 per cent. as above is very moderate, and should likewise be applied for the steam-engines.

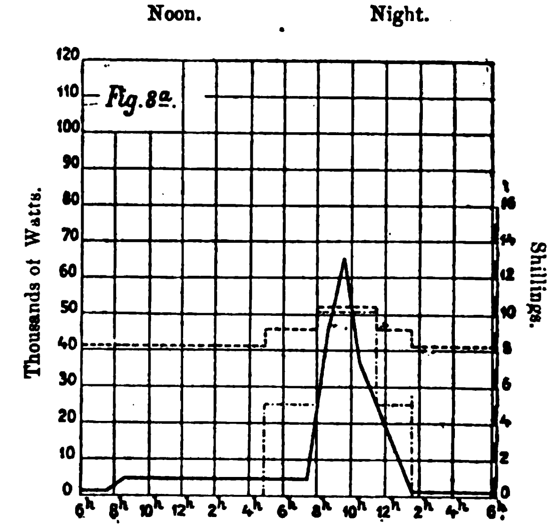
The coal consumption has next to be taken into account, and the results are plotted in Fig. 4 and Fig. 5, where the abscissæ are represented by the energy available at the central station and the ordinates by the prices in shillings per hour, so that it is possible to derive from them and the load diagrams mentioned in the beginning of this article, the areas of which represent the self costs of the running for one day; it will be found sufficient only to make this calculation for three characteristic days (December 22, March 22, and June 22). This is done in Figs. 6, 6a, 7, 7a, 8, 8a; the calculation gives

	Without accum.	With accum.
December 22	£11. 10s.	£11. 16s.
March 22	£10. 17s.	£10. 3s.
June 22	£10. 6s.	£9. 13s.









PARLIAMENTARY.

On Monday, in the House of Lords,

The **Duke of Marlborough** called the attention of the House to the fact that the period within which Her Majesty's Government can serve notices to terminate the existing licenses to the National Telephone Company expires the end of this month, and to move, "That in consequence of the recent declaration of the Postmaster-General in another place that the Post Office do not intend to undertake the work of the telephone as a branch of that department, it is advisable that licenses be granted to responsible parties who will be willing to undertake the business of forming new telephone companies on the expiry of the present patents owned by the National Company; and that competition is advisable in the interests of the public in order that the present exorbitant rates may find their proper level." The noble duke said that in answer to questions he had put in that House the Marquis of Salisbury had said that the matter was one of great public importance, and that it would be considered at some time during this year, and afterwards the noble marquis had said that the matter was under the consideration of the Government, who had not come to any decision as to the line they would adopt. Subsequently, in the other House, the Postmaster-General was asked whether the Government intended to exercise their powers to buy up the licenses and the telephones, and the answer was that the Government had no such intention. The question arose whether the admission of the Prime Minister that the matter was one of great public importance did not call for some further statement on the part of the Government. Their lordships must be more or less familiar with the uses to which telephones could be and were applied. There were telephones in nearly every considerable town on the Continent. In Paris there must be three or four times as many subscribers to telephones as there were in London. The comparative absence of telephones in London was partly due to the amount of money paid for patents and in the formation of companies, and partly to the want of facilities for extending the operations of the companies. When the telephone was first introduced the company owning it obtained a peculiar license from the Government. It was a license for 30 years to carry on business under certain restrictions and regulations, and the Government reserved the power to buy up the interests of the companies every seven years on giving a prescribed notice. The company agreed to pay to the Post Office a royalty of 10 per cent. of their gross receipts, and the company undertook that they would neither sell nor assign nor dispose of their powers without the consent in writing of the Postmaster-General. Any difference of opinion between the Government and the companies as to the valuation of their property was to be settled by arbitration; and the valuation was to include powers, privileges, works, and other property, but nothing was said as to plant, goodwill, or unearned increment. As the Government did not give the prescribed notice on June 30 last, to expire on December 31, it would now be December, 1897, before they could acquire the telephones. No one with any practical experience would venture to say what the Government might be called upon to pay, whether it would be one million or four millions. It would be a public benefit if the Government would acquire the whole telephone system at a cost of two or three millions, so as to enable them to enlarge the facilities for inexpensive telephonic communication; but as the Government would not do this, the public must look to the present companies. The United Telephone Company, which obtained the license from the Government, had paid high dividends, and they had pooled their interests with other companies. This company possessed all the Bell patents, for which they paid £370,000. The company formed subsidiary companies—the Lancashire and Yorkshire, the National, and one or two others—each of which had its own capital. When the telephone was proved to be a success, the shares of the United Company went up from £5 to £15, and the shares of the subsidiary companies, in which the original company had large holdings, also advanced considerably. A remonstrance was issued by the Postmaster-General against these transactions, which was in direct contravention of the clause in the license against the sale or assignment of the company's interests. The charge for a telephone in London was £20 a year, whereas the average charge for one in all the European capitals was £6 a year, and the English telephones being connected with single wires only were so subject to inductive and other disturbances that they were practically useless. To make them of real value they should be worked by means of double wires. If the houses in the West-end had a good telephone service it would save an enormous amount of correspondence, but in order to obtain an efficient service there ought to be competition. In the face of the agreement that the Postmaster-General had entered into with the National Telephone Company it would be most unfair, most unjust, and most improper for his department to enter into competition with the existing telephone companies, but that was no reason why he should not grant licenses to new companies who would probably make use of improved telephone systems much to the public advantage. Notwithstanding the fact that the National Telephone Company's capital had been what was vulgarly termed "watered" to the extent of £2,000,000, the price of their shares was still going up, which showed that the telephone business was a very paying one. He thought that the House was entitled to a clear statement on this subject from Her Majesty's Government as to what policy they intended to adopt with regard to telephones in the future. He should like to suggest that the Postmaster-General should keep the main telephone lines throughout the kingdom in his own hands, and should allow various companies to supply the local demands. He begged to make the motion which stood upon the paper in his name.

In reply, the **Earl of Jersey** said that the subject to which the noble duke had called attention was one of considerable interest, because any improvement in the means of our communication was always welcome to the public. It was not necessary that he should follow at any length the remarks of the noble duke, neither did he feel called upon either to defend or to attack the existing companies. He had observed that the noble duke had placed a construction upon the answer of the Postmaster-General in another place which it could hardly be said to bear. The Postmaster-General had said that the Government did not intend to give notice to purchase the undertakings of the telephone companies at the end of the year, but that answer did not debar the Post Office from undertaking telephonic work in cases where it might be thought necessary or desirable. The Government did not intend to adopt the policy of purchase by the State of the telephone companies. To do so would be to involve the State in a gigantic enterprise into which the Government were not prepared to enter. The Government intended to grant licenses to new companies which might apply for them, but, of course, each company would have to show that it was able to undertake the work for which it applied. The most important patent rights which gave a sort of monopoly to the present companies would expire in the middle of next year, and then competition would most likely arise, and in that way the public would reap with the least risk the benefits which the noble duke anticipated. He trusted that the noble duke would be satisfied with the statement he had made, and would withdraw his motion.

The **Duke of Marlborough** then asked leave to withdraw his motion.

The motion was by leave withdrawn.

LEGAL INTELLIGENCE.

EXPERIMENTAL LUBRICATING.

In the Westminster County Court, on Thursday, July 3, the case of Bolt *v.* The London Electric Supply Corporation came on for hearing before His Honour Judge Bayley.

The action was brought by Messrs. Bolt Bros. and Co., the well-known manufacturers of lubricating oils, to recover the sum of £42. 12s. 8d. for oil supplied to the defendant company.

Mr. Redman was counsel for the plaintiff, while Mr. Lynch conducted the case on behalf of the defendant company.

Mr. Lynch took a preliminary objection to one portion of the claim on the ground that the action was brought in respect of goods sold and delivered, while as a matter of fact some of the goods never had been delivered.

His Honour decided not to adjudicate upon that portion of the claim, and it was thus reduced to £21. 12s. 8d.

In opening the plaintiffs' case **Mr. Redman** said his clients were large suppliers of lubricating oils for electrical machinery, and were the inventors of a special oil known as "valdoline," which was a mixture of mineral and vegetable oil. In November, 1888, communications were opened up between the parties with a view to making certain experiments upon the machinery at the defendants' Grosvenor Gallery depot. Subsequently, an agreement was entered into by which the plaintiffs undertook to lubricate the defendants' machinery with their special oil for a term of one month, in order to test its efficacy. The experiments were arranged to commence on March 7, and the plaintiffs were, by the agreement, to be paid a sum of £50 for the month. One hundred gallons of oil were sent into the defendants' depot and the experiments were duly proceeded with, but turned out to be unsatisfactory, and were discontinued the same evening, and not afterwards proceeded with. The plaintiffs' case was that although the trial proved a failure, it was not due to any fault of the oil, but was wholly due to the inadequate tank provided for it. The oil had to be mixed with a certain quantity of water, and for that purpose it was necessary to have a large tank fixed above the machinery, but the tank fixed by the defendants was so small that the oil ran over, and some 50 gallons were wasted. The amount of oil and water which could be placed in the tank at one time was utterly inadequate to feed the machinery, and the consequence was that the bearings got hot.

Mr. Cleaton said he was the London manager to the plaintiffs' firm. He saw Mr. Sparks, the engineer to the defendant company, and arranged to prepare the special oil for the purpose of experimenting. He was quite satisfied that so far as the oil was concerned the trial would have been an unqualified success, and it was due only to the defendants themselves that the matter fell through. Ten drums of valdoline were supplied, and all of them had been returned empty, although nothing like that quantity of oil was used in the experiment.

Mr. Alfred Henry Walton, a mechanical engineer, said that valdoline was very extensively used for electrical purposes, but was usually mixed with water. In his opinion, the experiment ought to have been eminently satisfactory.

For the defence, **Mr. Lynch** submitted that in face of the existing written contract between the parties, the plaintiffs were not entitled to recover anything, but his clients had paid £1. 18s. into court as payment for the one day upon which the plaintiffs were engaged upon the experiments. A written contract was made by the defendants, and ratified by the plaintiffs, by which the latter undertook to carry out this experiment for a term of one month, and for their services they were to receive a sum of £50, but the

defendants reserved to themselves the right of terminating the experiments at any moment, if they proved to be unsatisfactory, without incurring any liability. Those terms were accepted by the plaintiffs, and the work was duly commenced, but turned out to be a disastrous failure, and the defendants, exercising their right under the agreement, refused to allow the experiments to proceed. The defendants themselves had been put to a loss of something like £100, and now they were to be called upon to pay a sum which was entirely contrary to the terms of the agreement. He (Mr. Lynch) ventured to submit that there was not the slightest ground for the claim set up by the plaintiffs, which was only done so as an afterthought, when they found that they would not be allowed to proceed with the experiments. On those grounds he (Mr. Lynch) should submit, with the greatest confidence, that he was entitled to a non-suit.

Without hearing any evidence for the defence, **His Honour** said he could not see how the plaintiffs could claim for these goods as goods sold and delivered. They were desirous of making these experiments, and for that purpose a quantity of oil was necessary, but, according to the terms of the agreement, plaintiffs were not to be paid unless the trial was successful. It was evident from what had been said by the witnesses that the trial was a failure, and that being so he (the learned judge) did not see how the plaintiffs could recover; therefore there must be a non-suit.

Mr. Lynch: With costs?

His Honour: Yes.

COMPANIES' MEETINGS.

WEST AFRICAN TELEGRAPH COMPANY, LIMITED.

The fifth ordinary general meeting of this Company was held last week at Winchester-house, Old Broad-street.

Sir John Pender, who presided, stated that the gross revenue for the year ended December last had been £64,661, or £9,346 in excess of that of the previous year. This increase had been derived almost entirely from traffic exchanged with South Africa. Communication between the Company's line and Cape Town was established on June 4, 1889, so that in that year they had had the benefit of this traffic for only about seven months. As the South African traffic was worked under a joint purse agreement between the Eastern, the Eastern and South African, the Brazilian Submarine, the Spanish National, and the West African Companies, as long as the communication was maintained by either coast of Africa their revenues were secured. The total expenses of the Company in the past year had been £21,155, or £1,139 in excess of those of 1888. They were enabled to recommend a dividend of 5 per cent. for the year, to charge repairs and renewals to revenue account, and to carry £16,145 to general reserve fund. He believed that their Company would play a very important part in the future of submarine telegraphy. If the Dark Continent was to be opened up they were prepared to do their part in the development of the country. He believed that the result of the late Telegraph Conference in Paris was that the cable companies now held a higher position than ever. On the whole they were fairly treated; but at the same time the tendency was always towards reductions of rates, which, however, it should not be forgotten, very often led to increased traffic. He concluded by moving the adoption of the report and the payment of a dividend of 6s. 6d. a share, making, with the interim dividend, 5 per cent. for the year.

Sir James Anderson seconded the motion, which was carried unanimously.

NEW COMPANIES REGISTERED.

S. Z. de Ferranti, Limited.—Registered by Ingledew, Ince, and Colt, St. Benet-chambers, Fenchurch-street, E.C., with a capital of £100,000 in £10 shares. Object: to acquire any electrical business, and the benefit of any patents relating thereto, and also to carry on the business of manufacturing engineers. The first subscribers are:

	Shares.
S. Z. de Ferranti, Charterhouse-square	1
F. Ince, St. Benet-chambers, E.C.	1
C. P. Sparks, Charterhouse-square, E.C.	1
F. W. Hunter, 2, Dashwood-road, Stroud Green	1
A. Wright, 3, Clement's-road, Brighton	1
H. W. Kolle, Egremont, Tulse-hill	1
G. B. Ince, St. Benet-chambers, E.C.	1

There shall not be less than two nor more than five Directors. The first are S. Z. de Ferranti, Francis Ince, and Charles Pratt Sparks. Qualification, 100 shares. Remuneration to be determined in general meeting.

Barry and Cardiff Electric Light and Power Supply Company, Limited.—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object: to carry on the business of electrical engineers.

Bristol Electricity Supply Company, Limited.—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object: to carry on the business of electrical engineers. The regulations contained in Table A, with slight modifications, apply.

Camberwell and Islington Electric Light and Power Supply Company, Limited.—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object: to carry on the business of electrical engineers.

Canterbury Electricity Supply Company, Limited.—Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £100, in £1 shares. Object: to carry on business as electrical engineers, etc. The regulations of Table A, with slight modifications, apply.

Cardiff Electricity Supply Company, Limited.—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object: to carry on the business of electrical engineers. The regulations in Table A, with slight modifications, apply.

Devonshire Electric Light and Power Supply Company, Limited.—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object: to carry on the business of electrical engineers.

East Coast Electric Light and Power Supply Company, Limited.—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000, in £1 shares. Object: to carry on the business of electrical engineers.

Hanley (Staffordshire) Electricity Supply Company.—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object: to carry on the business of electrical engineers. The regulations contained in Table A, with slight modifications, apply.

Ipswich Electricity Supply Company, Limited.—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object: to carry on the business of electrical engineers. The regulations contained in Table A, with slight modifications, apply.

Kent Patent Arc Lamp Company, Limited.—This is the title of an undertaking registered with a capital of £10,000 in £5 shares, to acquire any patents, lisences, or concessions in connection with electric or other lighting or illuminating purposes, in accordance with an agreement made between Messrs. J. Kent and Salter.

Kidderminster Electric Light and Power Supply Company, Limited.—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000, in £1 shares. Object: to carry on the business of electrical engineers.

Loughboro' Electricity Supply Company, Limited.—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100, in £1 shares. Object: to carry on the business of electrical engineers. The regulations contained in Table A, with slight modifications, apply.

Manchester Electricity Supply Company, Limited.—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100, in £1 shares. Object: to carry on the business of electrical engineers. The regulations contained in Table A, with slight modifications, apply.

New Cadogan and Belgrave Electric Supply Company, Limited.—Registered by Brook, Freeman, and Batley, 89, Chancery-lane, W.C., with a capital of £1,000 in £10 shares. Object: to carry on the business of electrical engineers, etc.

Northern Counties Electric Light and Power Supply Company, Limited.—Registered by N. Jennings, 13, Victoria-street, S.W., with a capital of £1,000, in £1 shares. Object: to carry on the business of electrical engineers, etc.

Paddington and Bayswater Electric Light and Power Supply Company, Limited.—Registered by N. Jennings, 13, Victoria-street, S.W., with a capital of £1,000, in £1 shares. Object: to carry on the business of electrical engineers, etc.

Penzance Electricity Supply Company, Limited.—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100, in £1 shares. Object: to carry on the business of electrical engineers. The regulations contained in Table A, with slight modifications, apply.

Provincial Electric Light and Power Supply Company, Limited.—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object: to carry on the business of electrical engineers.

Stamford Hill, Tottenham, and Edmonton Electric Light and Power Supply Company, Limited.—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object: to carry on the business of electrical engineers.

Weston-super-Mare Electricity Supply Company, Limited.—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object: to carry on the business of electrical engineers. The regulations contained in Table A, with slight modifications, apply.

Weymouth Electricity Supply Company, Limited.—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100, in £1 shares. Object: to carry on the business of electrical engineers. The regulations contained in Table A, with slight modifications, apply.

Woolwich District Electric Light Company, Limited.—Registered by George Whale, 54, Cannon-street, E.C., with a capital of £10,000, in £1 shares. Object: to carry on the business of an electric light company. Registered without articles of association.

CITY NOTES.

Direct Spanish Company.—The traffic receipts for June were £2,085, against £1,600.

Brazilian Submarine Telegraph Company.—The receipts for the week ended July 4 amounted to £4,481.

Telegraph Construction and Maintenance Company, Limited.—An interim distribution of 12s. per share is announced by this Company.

Great Northern Telegraph Company.—The receipts for June were £24,600, making an aggregate of £130,400, against £129,400 in 1889, and £132,000 in 1888.

Change of Firm.—The title of the firm known as Laurence, Paris, and Scott, Limited, of Norwich, has been changed to that of Messrs. Laurence, Scott, and Co., Limited.

Cuba Submarine Telegraph Company.—The estimated receipts for June were £3,300, as compared with £3,397 in the corresponding month of last year. The receipts for March, estimated at £4,000, realised £4,018.

Western and Brazilian Telegraph Company, Limited.—The receipts for the week ended July 4, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,451.

South of England Telephone Company, Limited —The Directors, in their report for the year ended April 30, recommend a dividend of ½ per cent., after placing £1,000 to reserve, leaving a balance of £382 to be carried forward.

F. H. Royce and Co.—This firm, whose works are at Cook-street, Hulme, Manchester, have sent us their revised price list of dynamos. Messrs. Royce state that they will be pleased to send a copy, post free, upon application to anyone interested in the subject of dynamos.

Eastern Telegraph Company, Limited.—This Company state that the accounts show, after placing about £120,000 to reserve fund, a balance available sufficient to pay the fixed dividend of 3s. per share, being at the rate of 6 per cent. per annum on the preference shares, less income tax, and a final payment of 2s. 6d. per share, with a bonus of 3s. per share, both tax free, on the ordinary shares, making, with previous payments, a total distribution of 6¼ per cent. on those shares for the year ended March 31.

Companies of the Month.—The following electrical companies were registered during the past month:

Beales, Limited, £1 shares	75,000
Bristol Electricity Supply Company, Limited, £1 shares	100
Column Printing Telegraph Company, Limited, £1 shares	100,000
Camberwell and Islington Electric Light and Power Company, Limited, £1 shares	1,000
Canterbury Electricity Supply Company, Limited, £1 shares	100
Cardiff Electricity Supply Company, Limited, £1 shares	100
Devonshire Electric Light and Power Company, Limited, £1 shares	1,000
East Coast Electric Light and Power Company, Limited, £1 shares	1,000
Hanley Electricity Supply Company, Limited, £1 shares	100
Ipswich Electricity Supply Company, Limited, £1 shares	100
Kidderminster Electric Light and Power Company, Limited, £1 shares	1,000
Loughborough Electricity Supply Company, Limited, £1 shares	100
Manchester Electricity Supply Company, Limited, £1 shares	100
Northern Counties Electric Light and Power Company, Limited, £1 shares	1,000
Paddington and Bayswater Electric Light and Power Company, Limited, £1 shares	1,000
Provincial Electric Light and Power Company, Limited, £1 shares	1,000
S. Z. de Ferranti, Limited, electricians, £10 shares	100,000
Stamford-hill, Tottenham, and Edmonton Electric Light and Power Company, Limited, £1 shares	1,000
Thetford Electric Light and Power Company, Limited, £10 shares	5,000
Weston-super-Mare Electricity Supply Company, Limited, £1 shares	100
Weymouth Electricity Supply Company, Limited, £1 shares	100
Woolwich District Electric Light Company, Limited, £1 shares	10,000

PROVISIONAL PATENTS, 1890.

JULY 1.

10125. **Improvements in electric cut-outs or apparatus for controlling the flow of currents of electrical energy.** James Leonard Kimball and Herbert Clarence Wirt, 55, Chancery-lane, London. (Complete specification.)

10131. **Improvements in secondary batteries.** Theodore Marshall Foote, 45, Southampton-buildings, London. (Complete specification.)

10134. **Improvements in covered or insulated electric cables or conductors, and a compound therefor.** James Yate Johnson, 47, Lincoln's-inn-fields, London. (John Haven Cheever, United States.) (Complete specification.)

10137. **Obtaining motive power by a method and means or apparatus in connection with any mechanical or electrical motor, or combination of both.** Philip Henry Williams, Egham, Surrey.

10183. **Improvements in electrical cut-outs, and fixtures connected therewith.** Henry Harris Lake, 45, Southampton-buildings, London. (Sigmund Bergmann, United States.)

10187. **Improvements in or appertaining to self-exciting electric generators.** William Phillips Thompson, 6, Lord-street, Liverpool. (William Stanley, junior, and Oliver B. Shallenberger, United States.)

JULY 2.

10211. **Improvements in electric primary batteries.** Vincent Fabris, 76, Chancery-lane, London.

10229. **Improved means for decomposing sewage water by oxiding zinc by electric current.** Alfred Green, 74, Whitegate-lane, Hollinwood, near Oldham.

10252. **Improvements in electric railways.** John Pitt Bayly, 18, Fulham-place, Paddington, London. (Thomas Aaron Evans, United States.)

10271. **An improvement relating to medico-electric batteries.** Noah Mitchell, 166, Fleet-street, London.

JULY 3.

10309. **An improvement in adjusting electric light suspenders.** Albert Lucas and Emil Sundborg, 61, George-street, Portman-square, London.

10316. **Improvements in joints for armoured electric conductors.** Joseph Devonport Finney Andrews, 28, Southampton-buildings, London.

JULY 4.

10359. **Improvements in connection with the electric lighting of ships.** Thomas William Watson and Arthur Henry Watson, 4, Pall-mall, London.

JULY 5.

10406. **Improvements in electrical measuring instruments.** John Perry, 31, Brunswick-square, London.

10421. **An improved method or means for the prevention of accidents from the overheating of electrical wires.** John Bradford, Poet's Corner, Westminster Abbey, London.

10445. **An improved electric prodpole.** John Pitt Bayly, 18, Fulham-place, Paddington, London. (John Burton, Edward Roach, Robert MacNair, W. P. MacNair, and Charles Lanning, United States.)

SPECIFICATIONS PUBLISHED

1885.

4671.* **Voltaic batteries.** FitzGerald. (Amended specification.) 8d.

1889.

6458. **Electric currents.** Hoho. 1s. 1d.

11528. **Electric accumulators.** Beyer and Hagen. 8d.

11832. **Electrical conductors.** Dolby. 6d.

12901. **Electric accumulators.** Crompton. 6d.

13322. **Transmitting electric signals.** Mercadier. 8d.

1890.

3924. **Electric batteries.** Lake (Crosby Electric Company.) 6d.

5782. **Electric lamp.** Hiorth. 6d.

6581. **Incandescence electric lamps.** Lake (La Société L'Incandescence Electrique). 6d.

7209. **Electric arc lighting.** Saunderson. 8d.

7383. **Battery element.** Levsen. 6d.

7465. **Telephone exchanges.** Kingsbury (Western Electric Company). 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2¾
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	10

NOTES.

Weybridge.—The installation of Messrs. Laing, Wharton, and Down at Weybridge, is, a correspondent informs us, running nicely.

Compressed Air and Electricity.—An international compressed air and electric supply company has been registered in Berlin with a capital of £1,500,000.

Exhibition at Palermo.—An international exhibition is to be held in Italy, at Palermo, in 1891, for which the Italian Government have granted a subvention of 1,000,000f.

Advertising Electrical Models.—Some enterprising shopkeepers have hit upon the idea of drawing attention to their wares by the installation of a model electric railway in their windows.

Companies.—Our readers should pay attention to the new companies formed, especially those connected with mining operations, as many intend to utilise electrical apparatus to a very considerable extent—since companies are being promoted for work in New Zealand.

Rotterdam.—The electric lighting of the town of Rotterdam is to be placed in the hands of the Corporation Gas Committee. A considerable sum is to be spent in testing various systems for public lighting, after which the conditions will be arranged for the private supply.

Berlin Telephones.—The whole network of the telephone service at Berlin is being placed underground. This great undertaking is to cost 1,863,000 marks. The conduits are from 7½in. to 15in. wide, and will contain from 20 to 80 conductors. Berlin will then contain the largest subterranean telephone service in the world. The number of subscribers at present is over 15,000.

Elberfeld-Barmen Electric Road.—The communal councils of the towns contiguous to Elberfeld and Barmen have accepted the proposal of Messrs. Siemens and Halske, to construct and carry on at their own risk an electric street railway on the overhead system passing through the two towns, a distance of about five miles. The works will shortly commence. The line presents very favourable conditions for economical working.

The Khojak Tunnel.—It is estimated that the total cost of the Khojak tunnel will be five lakhs of rupees, and that it will be nearly twelve months yet before the work is entirely finished. There are at present about 40 European miners and a large number of natives employed on the works. The tunnel can now be lighted throughout with the electric light, and fresh air is continually being pumped down by machinery through the shaft.

Amsterdam.—The Bill has recently been passed fixing the regulations for the public lighting of Amsterdam to be tendered for publicly before September. The contractors are to pay 5 per cent. per annum on all receipts, and of the balance 6 per cent. is to go to the contractors, and after this half the surplus, the other half going to the consumers. The Council reserve the right to readjust the charges every five years, and may insist on their being lowered if deemed excessive.

Frankfort Exhibition.—The committee of the approaching exhibition at Frankfort had made arrangements to supply energy, electric, steam, water or gas, at a price equal to 1·8d. per h.p. hour. This tariff has now been rearranged on a more favourable sliding scale. Steam will be supplied to engines of 1 to 50 h.p. at 60s.; 50 to 100 h.p. at 50s.; 100 to 300 h.p. at 40s.; and over 300 h.p. at 30s. per h.p. for the whole period of the exhibition without consideration of the days and hours of working.

The Electric Light in Northumberland.—In addition to the intimations given to the Blyth and Alnwick authorities, notices have been sent to the Morpeth Town Council, to the Amble Board, and to the Cramlington Local Board that a Northern company means to apply to the Board of Trade for power to supply the electric light in each of their respective districts. The Morpeth Council decided to discuss the matter at a future time. At Cramlington, the chairman (Mr. Richardson) expressed the opinion that the cost of the light in that district at least would not permit it to pay.

Brighton Accident.—The damages in the electric light accident at Brighton awarded at £800 recently came before the Queen's Bench Divisional Court on motion for a new trial, as it was maintained the amount was excessive. In support of the motion, it was stated that the deceased earned 22s. per week, of which 17s. went to support the family. The sum awarded was thus sufficient to purchase a life annuity for this amount; and it had been laid down in various cases that damages to such an extent would be excessive. After some discussion, it was arranged for the damages to be reduced to £500.

Electrical Bureau.—A useful organisation has been founded at Chicago under the name of the National Engineering Bureau. The objects and purposes of the Bureau are the superintendence of mechanical and electrical engineering, specifications for electric light wiring and electric light plants, indicating engines, testing and inspecting electric construction. The engineers are gentlemen of practical knowledge and experience. No doubt such an organisation under capable superintendence, with a fixed and reasonable scale of charges, would prove useful in various large commercial centres.

Pole-Finding Paper.—Messrs. Berend and Co., the agents, send us a book of Wilke's pole-finding paper. It is said to give the most reliable, simple, and handy means of quickly and correctly ascertaining the direction of electric currents and of testing for leakage. A strip of paper—the leaves are perforated—is detached from the book, moistened by the tongue, and placed on a clean piece of wood. Then touching the paper with the wire to be tested causes a red spot to appear at the point, where it is touched by the wire is the negative wire. Each book contains enough paper for hundreds of tests, and is small enough to be carried in the pocket.

Twenty-Pound Volts.—In describing an accident which happened to a dynamo at the California Electric Light Company's works, the other day, a bright reporter on one of the San Francisco leading dailies stated that, "When the armature (which was 4ft. in diameter) had attained a speed of about 1,000 revolutions per minute, the centrifugal force was so great that the magnets flew from the periphery at various tangents with terrific force, and that the volts (big fellows, weighing 20lb. each) whizzed through the air with the velocity of cannon balls, and buried themselves in the walls of the establishment! One man was injured, though not seriously," hit, probably, by one of the flying volts!

Electric Ploughing.—It is stated that the German Electric Company established at Madrid is contemplating the installation of a plant for electric ploughing on a large property in the central part of Spain. This seems, says the

correspondent of *Industries* who sends the item, rather an expensive and useless experiment. We suppose, however, if electric transmission of power is to be practical, it may be useful for ploughing as well as for other uses. The main point to enquire seems to be the source of motive power. If from water power the experiment may prove less expensive than other means, and at any rate if properly carried out cannot fail to be interesting both to electrical engineers and progressive agriculturists.

Foots Cray.—At a meeting of the Foots Cray Parochial Committee on Monday a communication was read from the engineer's office of the General Telegraph Department intimating that lines of telegraph wire were about to be laid between London and Folkestone, and asking leave to erect the necessary posts. Mr. Wade thought this was a matter which would concern the County Council. The clerk said that it would also concern the local authorities, as the posts might at points be placed on the footpaths. Mr. Martin said something ought to be said against the unsightliness of posts in the main road. It was stated that the chimneys would not be safe, as there was going to be six or seven wires. It was then decided to object to the erection of poles and wires in the main road.

Bromley.—A deputation from the Electric Light Syndicate at Bromley visited Bath on Monday last, under the guidance of Mr. Schiassi, to see the system of lighting at Bath. The deputation visited Mr. Massingham's station, and every effort was made and facility given by that gentleman so that the fullest information might be obtained. The evening was dark and stormy, giving a favourable opportunity for seeing the effect of the light when most required. The deputation expressed themselves as highly gratified with the light, and the industry will have once more to thank Mr. Massingham for his energy—as many have gone to see his work at Taunton and Bath, and have been convinced that the light is efficient and practicable. We trust that the report of the deputation may stir up the inhabitants of this wealthy suburb to greater activity in obtaining more light.

Electric Quacks.—At last the *Times* has permitted a correspondent to describe her experience of electric quackery. In this case a lady seems to have desired the removal of "hair from the face," to have read a pamphlet from some electric charlatan, and to have tried the remedy. The hairs were removed, but naturally grew again, so that a razor would have performed the operation as well, at the cost of a penny instead of some twenty or thirty pounds. Readers of technical papers do not form the *clientèle* of electric quacks, and the only way to counteract this charlatanism is to get the newspapers to expose it. But then how about the advertisements, which form so large a part of the income of such papers? Moral: Have nothing to do with electric pads, hair-brushes, pain-killers, etc., and if in doubt about any question of the kind, consult one or other of the technical papers.

Pocket-Books.—We have received two pocket-books compiled for the use of electrical engineers. The most important is that by H. R. Kempe, whose admirable book on testing is so widely known. This book is published by Messrs. Crosby, Lockwood, and Son, and, as might be expected, has been most carefully compiled. The value of such a book consists principally in the arrangement, and in nothing being inserted that is not frequently wanted, and nothing left out that is frequently wanted. The time at our disposal since the receipt of this book has been too short to enable a thorough investigation, but from a cursory examination we are satisfied that it is the best book of its kind as yet issued, and will prove of great use. The second book is by Mr. F. Walker, and is published by Iliffe and Son, consisting of 29 pages only, and is interleaved. It contains various useful tables, and information relating to traction, marine propulsion, units, indicators, etc.

A Fee-Taking Telephone.—A penny-in-the-slot telephone is in use in the New Haven House, Connecticut. It cannot be used unless a fee is paid. It is understood there are only two instruments of the kind in existence, the other being in Hartford. There are five slots in the machine for the reception of various coins, covering the rates charged for telephoning to various places in and out of the State. To use the telephone it is first necessary to call up the central, as on an ordinary telephone. The place required is then asked for, and when this is reached the party who rings up is told to put the necessary fee in the slot. If a copper is dropped in a bell of high tone rings. For higher fees the tone becomes lower in inverse ratio, and for half a dollar the sound is like that of the average door bell. The dollar sound is similar to that of a fire-alarm gong. The sound of the bell is the signal to go ahead and talk. The contrivance is the invention of William Gray, of Hartford. A company has been formed for the manufacture of the instruments.

A New Electrical Railway Clock.—An electrical self-winding and synchronising clock has been devised by W. W. Bradley, formerly of Waterbury, and now manager of the Dueber Watch Case Company, of Canton, Ohio, together with W. N. Parker, electrician. The clock has but five wheels, and is run without springs. As a time-keeper, it is said to be almost perfect, showing a variation of only four seconds in 55 days, which leaves it without a rival as a time-keeper. Sealed up, it will register true time for two years, the synchroniser rectifying the few seconds variation. A special feature especially useful for railway service is the automatic electrical switch lock, enabling the operator at the observatory, or wherever the master clock is located, to have a full control of all clocks connected by wire to the master clock. No attention is required at the separate stations, and no meddling can affect the synchroniser. Clocks can be synchronised at any hour or half hour desired, from the observatory, and while the telegraph wires are doing full service.

Flaw Detector.—The method or instrument devised by Capitaine du Place as a modification of Prof. Hughes' sonometer, which he terms the schiseophone, may be used, it is stated, in workshops for detecting flaws in axles and crankshafts, and experiments made in the engine shops at Ermost of the Chemin de Fer du Nord in France are said to have been very successful. The instrument comprises a striker and an audiometer. A steel rod is moved to and fro in front of a microphone, periodically striking the metal bar under examination. Two coils, one movable and connected to the microphone, the other fixed and connected to two telephones, are arranged on a graduated rod. Having placed the movable coil so that the telephones are silent so long as the hammer is striking a solid portion of the metal, the hammer is moved along the bar, and should there exist a flaw in it, the increased noise given out causes more powerful currents to flow in the microphone circuit, with the result that the telephones are no longer silent. When experience has been gained it may be that such a method will be found exceedingly useful in locomotive axles and propeller shafts.

Cardiff.—The residents of Broadway are agitating for more light. A deputation that waited upon the Lighting Committee a few days ago were promised that the matter should be favourably considered, and subsequently the borough engineer was ordered to report on the requirements. The committee also received another deputation representing the Brush Company, to obtain the support of the committee for the Brush provisional order. Mr. Garcke was present, as was Mr. Deakin, the local manager. Mr. Garcke explained the position of affairs, and answered a number of questions. It was pointed out that seven other companies, in addition to the Corporation, were applying for similar powers. After the deputation had gone Mr. Carr proposed that a special meeting be called to consider the matter, and that in the meantime the town clerk be instructed to ascertain if any corporate bodies had obtained provisional orders, and had granted them to electric lighting companies, and if so, upon what terms; also that the engineer procure particulars as to subways in use in other towns, the laying of subways in Cardiff, and other details. Mr. Ramsdale seconded the motion, and it was carried.

Bimetallic Wires.—The Société Fonderies, Laminoirs et Tréfileries of Joinville-le-Pont, says the *Bulletin Internationale de l'Electricité*, is now manufacturing bimetallic wires for telegraph, telephone, or other purposes, of which tests, made by the French Post Office authorities, show the following results:

	Number of coils tested. 1.	2.	3.	4.
Diameter	1·97mm.	1·88mm.	1·89mm.	1·95mm.
Breaking stress	493lb.	493lb.	449lb.	603lb.
Lenthening ...	16·17mm.	26·23mm.	19·20mm.	19·21mm.
Weight	57·2lb.	55·7lb.	55·2lb.	55lb.
Resistance per kilometre in ohms at 0deg. cent.	8·66	9·69	8·98	9·52

It appears that a bimetallic wire of 19/10 has the same conductivity as a copper wire of 15/10, and the same breaking stress as a copper wire of 25/10 If these qualities are justified by practice, they would allow a sensible economy in the cost for long-distance telephone lines, and even over galvanised iron telegraph wires, as the diameter of these must be 46/10 to attain the same conductivity as is given by a bimetallic wire of 19/10.

Telephoning to Trains.—The idea of telephoning to trains in motion without the aid of a metallic contact has been promulgated by Edison, but has not yet come much into practical work. A further, if less original, method has been lately tried with considerable success of the electric railway signal of the Universal Electric Railway Signal Company of Richmond, Virginia. About three miles of the railway line on the Baltimore and Ohio Railway has been fitted with their system by way of experiment. The apparatus consists of an electric circuit formed by a single iron rod laid between the rails, and a wire brush attached to each engine in connection with an electric gong and telephone. Two engines if approaching each other on the same track come into circuit at the distance of one mile and a half or more, according to strength of the battery, and at once the telephone bells ring. This is a signal for the trains to stop, and the engineers can then talk with each other on the telephone to discover the trouble, whatever it may be. On the occasion of the trial two trains were sent out on the Baltimore and Ohio line with a party of gentlemen interested and press correspondents of newspapers in different parts of the country, and the tests made proved extremely satisfactory.

Cannes.—We have already mentioned that the town of Cannes, in the South of France, is considering the means for the lighting of the town by electricity. The Municipality have been applied to for the concession by an electric company, for running mains either overhead or underground for the distribution of electric light. A syndicate of the hotel proprietors has treated provisionally and conditionally with this company for an installation of 2,000 lamps (power not stated) at the price of 51·5f. per lamp for a period of six to seven hours a day during 7½ months (October to May). The Municipal Council have referred the consideration of the question to a commission composed of members of the Council. The minimum installation assured is 2,000 lamps for the hotels. Besides a considerable business population, there are several hundreds of villas belonging to rich families which might be supposed willing to adopt the light. There is, therefore, the basis of a considerable and profitable undertaking, and before deciding upon the concession asked, the commission have decided to invite other tenders possibly on a basis more favourable to the public or at any rate to private consumers, for the public lighting has been granted to a gas company, and cannot be changed until 12 towns more important than Cannes have adopted a lighting other than gas.

Electric Light for Bombay.—According to the *Indian Engineer* it was proposed at a recent meeting of the Standing Committee of the Bombay Municipality, that the Municipal Commissioner be asked what was the present position as to the proposed introduction of electric lighting in Bombay in a part of the city. Mr. Ollivant, the late commissioner, had put forward a scheme some time ago for electric lighting in certain parts of the city, but that was a very big scheme, and it was not carried out. There was a provision for 30,000rs. in last year's budget for electric lighting in Bombay. Mr. Acworth, municipal commissioner, on June 24 made a statement before the Standing Committee of the Corporation regarding the proposed electric lighting in Bombay. He said that, in response to the advertisements published by his predecessor in the local and English and American papers, there were four tenders received for the electric lighting of the city. The committee resolved that the commissioner be requested to prepare a special report on the subject of electric lighting, containing full details of the scheme proposed to be adopted in connection with the carrying out of the experimental electric lighting, and that he be authorised to apply to Government for the services of an electrical engineer, and that in order to enable him to make the necessary scientific enquiries he be further authorised to expend a sum not exceeding 1,000rs.

New Spanish Electrical Journal.—We have received the first number of a new Spanish electro-technical journal, *La Ciencia Eléctrica* ("Electrical Science") published at Almirante, 21, Madrid, fortnightly, the subscription being 30f. On the title-page is a full list of collaborateurs whose support is promised for the journal, comprising some of the most distinguished engineers, civil and military, electricians, and professors in Spain. It is hoped to make the journal a representative one for Spain, and that works of an original nature and of correct and extensive information of work carried out will be given in the fields of electrical science. The progress of the electrical industry has been considerable, and it will be the province of this journal to put this in evidence. It is hoped that foreign electrical engineers having an interest in Spain and Spanish-speaking

countries will co-operate. The journal will print an edition of 5,000 copies, of which 2,000 will be circulated in South America, Mexico, the Antilles and Philippine Islands. The journal has a neat slate-grey cover, with an artistic title-page. The first number contains articles on electric meters, duplex telegraphy, description and illustrations of the Madrid central installation, with portraits of its engineers, articles upon the source of electrical potential, the direct cable between Spain and Antilles, the "Peral" torpedo, and notes on industrial developments in Spain. We wish the undertaking the heartiest success.

The Age of Electricity.—A fair idea of the wonderful strides that the application of electricity to all and every purpose is now taking, and may be expected to take, can be gathered from a recent article in the New York *Sun* on electric power, in which the work of the motor is summed up as follows: "In some cities, so far has the use of electric motors gone, that it is possible for a man to-day to drink at breakfast coffee ground and eat fruit evaporated by electric power. During the morning he will conduct his business with electrically-made pens, and paper ruled by electricity, and make his records in electrically-bound books, his seventh-storey office in all probability being reached by an electric motor elevator. At luncheon he will be able to discuss sausages, butter and bread, and at night eat ice cream and drink iced water due to the same electrical energy. He will ride all about the place in electric cars, wear shirts and collars mangled and ironed by electric motor, sport a suit of clothes sewn and a hat blocked by the same means; on holidays ride a merry-go-round propelled by electric motor, or have his toboggan hauled up the slide with equal facility, be called to church by an electrically-tapped bell, sing hymns to the accompaniment of an electrically-blown organ, be buried in a coffin of electric make, and, last of all, have his name carved on his tombstone by the same subtle, mysterious, all-pervasive and indefatigable agency. This may sound like a wild and exuberant flight of fancy, but it is simply a faithful statement of the manner in which electricity is being applied to everyone of the necessities and luxuries of life in America."

Niagara.—A syndicate in the United States have acquired a considerable area of land on the American side of the Niagara river at some distance above the great falls. They propose to use it for mill sites, and to supply the mills with power by utilising a small fraction of the water power which is available on the falls. The actual fall of level at Niagara is about 200ft. It is proposed to take the water by a short lateral canal, to allow it to descend vertically in shafts in which turbines will be placed, and then to discharge it by a tunnel tail race passing beneath the present town of Niagara at a point below the falls, It is part of the plan to transmit a portion of the power to the important manufacturing town of Buffalo 18 miles distant. The project involves problems of very great complexity. The hydraulic motors will be of a size not hitherto constructed, and the governing conditions are different from those commonly met with where water power is utilised on streams of variable and limited flow. Then in the distribution of the power further problems arise. In Switzerland and America progress has been made in distributing large power to great distances electrically. The Cataract Company have resolved to invite from certain selected engineers and engineering firms plans for the utilisation at Niagara of 120,000 horse-power, and to submit the plans for an authoritative opinion to the judgment of a scientific international commission. The commission will consist of Sir William Thomson, F.R.S., as president; Prof. Mascart, member of the Institute and director of the Bureau Central Météorologique, Paris; Colonel Theodore Turrettini, who was director of the works of the St. Gothard Tunnel, and is director of the works for the utilisation of the motive power of the Rhone at Geneva; and, lastly, Dr. Colemen Sellers, formerly of the firm of Messrs. Sellers and Co., of Philadelphia, and now professor of engineering at the Stevens Institute, Hoboken, and at the Franklin Institute of Pennsylvania. Prof. W. C. Unwin, F.R.S., M.I.C.E., is the secretary to the commission.

Barnsley.—The Lighting Committee of the Barnsley Town Council have prepared a report on the subject of electric lighting, in which they recommend "That the tender be accepted of the Westinghouse Company for the construction of electric lighting plant to light the area mentioned in the second schedule to the provisional order, subject to the terms of the tender being embodied in a contract to be prepared by the town clerk, and subject to the system of the Westinghouse Electric Company receiving the approval, in writing, of the Board of Trade." The inner area referred to comprises practically the whole of the business part of Barnsley, and the tender amounts to £17,800. For a year past the committee have been considering the question of lighting the town by electricity, a provisional order for the purpose has been obtained, and tenders in various forms received and considered. Tenders for the execution and maintenance of all the works needed for the supply of electricity for lighting and motive purposes were first asked for; but owing to the "high charges and excessive terms of purchase asked by the companies" the committee were compelled "to relinquish all ideas of introducing the electric light to Barnsley by the medium of a private company." Tenders for erecting and supplying a plant requisite for the Corporation to light the inner area—practically the business centre of the town—were then asked for and obtained as follows: The Gulcher (New) Electric Light and Power Company, Limited, £25,500; Electric Construction Corporation, Limited, two tenders, £22,751 and £21,721; Manchester Edison-Swan Company, Limited, £19,200; Westinghouse Electric Company, Limited, £17,800; Laing, Wharton, and Down Construction Syndicate, Limited, £16,975; Brush Electrical Engineering Company, Limited, £13,100; National Electric Supply Company, Limited, £11,188. Mr. A. Bromley Holmes has been adviser; and, acting upon his advice, the committee make the above recommendation. He estimates the cost of maintenance as follows: coal, water, oil, waste, etc., £1,450; renewal of carbons and street incandescents, £225; salary of chief engineer and assistant, £350; wages of enginemen, stokers, linemen, and labourers, £936; collector and clerk's assistance, £200; sundry expenses, £200; total, £3,361. Interest, sinking fund, 5 per cent. on cost of site and buildings, £4,000, equal to £200; 10 per cent. on cost of plant, etc., including repairs, £18,500, equal to £1,850; total annual estimated cost, £5,411. Assuming all the incandescent lamps provided for in the scheme to be used at 6d. per unit, they would give a revenue of £4,000, leaving £1,411 to set off against the street lighting. The street lights would replace 248 gas-lamps, giving a total light of 6,574 candles, at a cost of £800. The street lights proposed to be substituted for these would give a light of 54,480 candles, and extensions beyond the area would cost £50 for each arc lamp, and £10 for each 32-c.p. incandescent lamp.

THE WORKING EFFICIENCY OF SECONDARY CELLS.*

BY W. E. AYRTON; C. G. LAMB, E. W. SMITH, AND M. W. WOODS, ASSOCIATES.

I.—PREVIOUS TESTS OF CELLS.

Since 1881, when the formation of Planté storage cells was greatly accelerated by Faure's device of pasting the plates, numerous tests have been made in different parts of the world on the capacity and efficiency of secondary cells. The first tests that were carried out were conducted simultaneously, at the end of 1881, in England by Prof. Perry, with one of the authors of this paper, and in France by a committee consisting of Messrs. Tresca, Potier, Joubert, and Allard, working at the Conservatoire des Arts at Metiers, with a staff of assistants.

In the report—communicated to the Physical Society in February, 1882—by the two English experimenters, it was pointed out that the great "resuscitating power" of the cells made it very difficult to say when they were entirely discharged, and, therefore, in order to test the efficiency, the cells were first "emptied" of charge by discharging them until the discharge current was very small, and finally leaving them short-circuited for many hours with a short bit of thick wire. Next, a measured amount of energy was put in these "empty" cells, and they were then thoroughly discharged on three successive days, being insulated and allowed to recuperate during the two intervening nights. Although the energy efficiency thus obtained, and which was not less than 82 per cent., probably represented much more than could be obtained in practice at that period, if the discharge were stopped before the E.M.F. fell to so low a value, this efficiency represented something quite definite, since all the energy given out by the cells in the discharge must have been put into them during the measured charge, no demand being made on some inexhausted store of energy previously put into the cells.

The French Committee, on the other hand, considered the cells as being discharged when a certain current which was originally produced through a fixed resistance by 30 cells could no longer be kept up, even when the number of cells had been increased to 35. But unless, subsequently to the receipt of the cells from the manufacturers, they had been charged and discharged several times until the same cycles of values of E.M.F. with time were repeated with each charge and discharge, there was no guarantee that in the experimental discharge the cells were not drawing on a store of energy put into them before leaving the manufacturers' premises, and thus giving a higher value than the "working efficiency."

And we are afraid that a very possible neglect of the powerful resuscitating power of accumulators may have vitiated some of the published results of experiments that have been made on them. This doubt must not be forgotten in considering the accompanying list, which is as complete as we have been able to make it, of all such experiments that have been made up to date. At the middle of 1889, when we had nearly completed our investigation, there appeared two very important contributions to the subject—one on "The Inherent Defects of Secondary Batteries," by Dr. Louis Duncan and H. Wiegand; the other, "Ergebnisse von Versuchen an Akkumulatoren für Stationsbetrieb," by Prof. W. Kohlrausch and C. Heim. These investigations are extremely interesting, as they confirm some of the results which we had also arrived at, and to which reference will be made in this paper; Prof. W. Kohlrausch and C. Heim, for example, laying great stress on the fact that the discharge of an accumulator does not depend merely on the previous charge, but on the previous history of the cell.

At the Central Institution there are three distinct types of E.P.S. cells in daily use. The cells, however, used by us for the investigation were 20 out of a group of 50 of what is known as the 1888 type. This type we selected since it was the latest constructed by the Electrical Power Storage Company. The particular specimens of this 1888 type which are at the Central Institution contain each two positive and three negative plates, each plate, exclusive of the lugs, being 9¼in. by 9¼in. The glass vessels containing these plates are large enough to each hold 7L plates, but we preferred to use 7L glass boxes to having smaller boxes specially constructed.

The total weight of each of these cells is about 59lb. 12oz., made up as follows:

		lb.	oz.
Three negative plates	about	17	2
Two positive "	"	11	8
Ebonite strips	"	0	8
One glass vessel	"	7	8
Dilute sulphuric acid	"	23	2

and the cells are intended to be used with a maximum current of nine amperes on charging and 10 on discharging.

The first point to settle with reference to the discharge was whether the resistance in the circuit should be kept constant, or whether as the E.M.F. fell the resistance should be varied in such a way as to keep the current constant. This latter method, although it involved much more labour, was adopted. At first the current was kept constant by varying the resistance by hand as the E.M.F. of the cells altered. But this required the constant presence of one of the observers day and night, partly to vary the resistance from time to time, and partly to start the charging directly the discharging was finished, in order that the cells might never be left discharged. Hence, an automatic arrangement, which will be described later on, was subsequently devised, and by means of it the current was maintained more constant than could be achieved by even very careful hand regulation, and the circuit broken during discharging and during charging the moment the P.D. reached certain pre-arranged values.

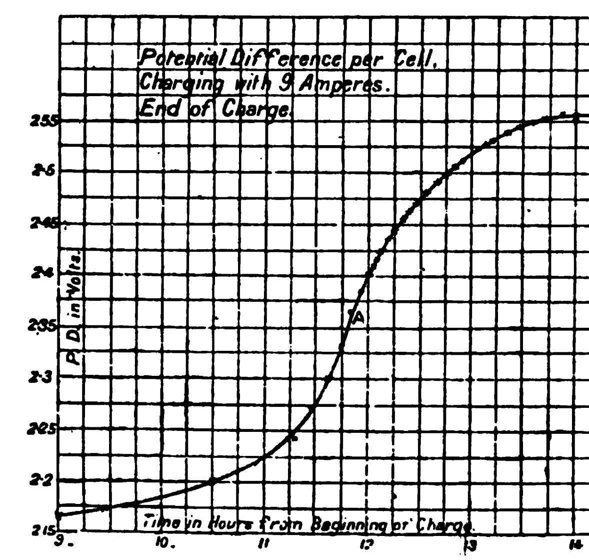


FIG. 1.

We had next to adopt a criterion by which to settle when a charge or discharge could be said to be completed. Such a criterion may be made to depend on a variety of changes that take place in a cell, three of which are in common use—viz., change in the specific gravity, gassing, and change in the P.D. In the case of the cells tested by us, and which have more liquid in proportion to the plates than is usually the case, the change in specific gravity from charge to discharge is from 1·2 to about 1·17; and, as our experiments show that the change is directly proportional to the time, when the current is kept constant, the change in the specific gravity per hour is only about 0·002, which is far too small to be read very accurately with ordinary hydrometers. But it is known the fall in the E.M.F. of the cells at the end of the discharge is very rapid, so that half an hour more or less in the time of discharge produces a great difference in the value of the E.M.F.; hence it follows that, if a specific gravity test were alone employed with our cells as a criterion of charge and discharge, it would be necessary to read the specific gravity accurately to less than 0·001 at the end of the discharge. The amount of gassing is also far too rough a test, and can-

* Paper read before the meeting of the Institution of Electrical Engineers at Edinburgh, July 16, 1890.

TABLE A.—EFFICIENCY TESTS OF ACCUMULATORS.

Date.	Maker of cell.	Experimenters.	Efficiency.		Remarks.
			Quantity	Energy.	
1882	Faure	Ayrton and Perry......	...	82	Cells short-circuited for some time before being tested. Cells discharged on three successive days, and allowed to recuperate during the two intervening nights.
1882	"	French Commission ...	92	70	Result of a week's work. Current kept fairly constant during discharge by the addition from time to time of fresh cells.
1883	Schultz	Hallwachs	...	6 to 50	Results variable and indefinite.
1883	E. P. S.	H. Morton	90	...	
1883	......	Aron..	...	6 to 50	Results very variable.
1885	B. T. K.	Forbes......	80	69	Mean of one week's work. Current not kept constant.
1886	Farbaky & Schenek	Waltenhofen	91·7	78·7	
1886	E. P. S.	Drake and Gorham ...	90	80	Current maintained constant during charge and during discharge.
1887	......	Haeberlin	92	...	"Cells not good."
1887	Fitzgerald..............	Lea	91	...	
1887	......	Huber	...	88	
1887	C. Smith	Miller	80	..	Lead spirals painted over with salts.
1888	Huber	W. Kohlrausch	90·7	78·4	
1889	Farbaky & Schenek	Waltenhofen	88·1	77·4	
1889	Tudor	W. Kohlrausch & Heim	[illegible]	82·4	Normal currents used in charging and in discharging.
	"	" "	77	64·7	Charging and discharging currents rather more than twice the normal.
	"	" "	81·4	71·7	Cells allowed to rest for 160 hours after charging.
	"	" "	90	80	Cells first completely discharged by the external resistance being gradually diminished to nought.
					The positive plates of these Tudor cells are first formed by Planté's process, then the holes in the grids are filled with minium, and the forming continued. The negative grids are not formed at all, but merely have the holes in the grids filled with lead oxide.

not be employed at all in the discharge, hence we were led to resort to the variation in the P.D.

A number of experiments were now made on two of the cells in order that the exact shape of the curves of P.D. at the end of the charge and discharge might be ascertained. The curve shown in Fig. 1 is the end of the P.D. curve for one cell on charging with nine amperes

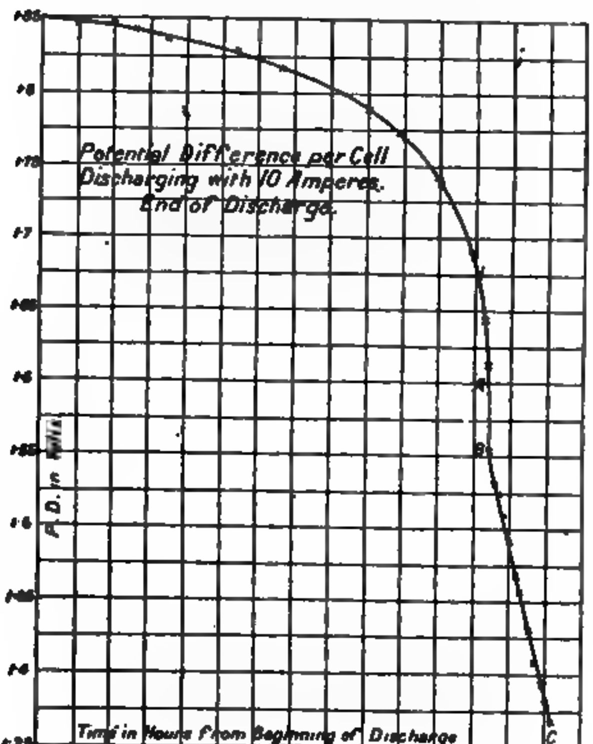


FIG. 2.

for 14 hours; from which we see that the rate of variation of the P.D. with time is greatest when the P.D. is about 2·36 volts, indicated by the point A. In Fig. 2 is shown the curve of P.D. during the last $3\frac{1}{2}$ hours of a discharge with 10 amperes, the discharge being continued for 12 hours. In this particular experiment the discharge was allowed to continue until the P.D. fell to 1·365 volts, indicated by the point C, which is far lower than we have dared on any other occasion to allow the P.D. to fall. At about 1·8 volts the P.D. curve begins to fall pretty rapidly, and the slope of the curve, or the rate of diminution of the P.D. with time, goes on increasing until the P.D. has fallen to 1·6 volts, indicated by the point A on the curve in Fig. 2. Here $\frac{dV}{dt}$ per cell has reached a value 1·4, V being measured in volts and t in hours. Below this the curve has a shape that has not hitherto been noticed, for when the P.D. per cell has reached 1·556 volts, indicated by the point B, the curve suddenly alters its shape, becoming the straight

FIG. 3.

FIG. 4.

line BC, with a less inclination to the axis of time, $\frac{dV}{dt}$ being for this line only 0·44.

Just as we have in the curve in Fig. 2 continued the discharge much below the usual limit, so we examined what would take place if the charging was also prolonged much beyond the usual limit. Curve 3 shows the rise of the P.D. when the charging at 4·52 amperes was continued for $37\frac{1}{2}$ hours, $25\frac{1}{2}$ hours being sufficient to fully charge the cells with this constant current of 4·52 amperes—that is, to charge them until the P.D. per cell was 2·4 volts. It will be observed that whereas the volts rise from 2·25 to

Group of 10 Cells.—No. II.

Discharge at 4·858 amperes.		Charge at 9·104 amperes.		Percentage.	
Ampere-hours.	Watt-hours.	Ampere-hours.	Watt-hours.	Quantity efficiency.	Energy efficiency.
154·5	3,005	138·5	2,910	111·5	103
141·5	2,770	129·7	2,820	109	98
Discharge at 4·858 amperes.		Charge at 4·519 amperes.			
143	2,785	141	3,075	102	90·5

Now, not only are quantity efficiencies of 105, 103, 111, 109, etc., per cent. impossible, but energy efficiencies of 94, 92 per cent. are also too high, when accumulators are being charged and discharged at the maximum rate allowed by the manufacturers. Further, it is noticeable that for each set of tests both the quantity and energy efficiencies diminish on the whole as the tests proceed. These cells, like the other cells in the Central Institution laboratories, have been charged at regular times; and as the number of ampere-hours taken out of them for ordinary laboratory work varies very much, the intervals between the periodic chargings are so arranged that on the whole the cells are charged up much more than they are discharged.

Hence at the commencement of these tests the cells had a large store of energy in them on which to draw in the discharges, the results of which are given in the preceding table. From this we learn this very important fact—that *if accumulators be thoroughly well charged up before being tested, then five days' continuous charging and discharging alternately with even the maximum currents allowed by the manufacturers fails to give the normal quantity, or energy, efficiency.*

It will be noticed that both the ampere-hours and the watt-hours are increased by diminishing the current employed. This is partly due to the fact that if a fixed P.D. limit per cell be employed either in discharging or charging, the cell is discharged until the E.M.F. is slightly lower, and charged until the E.M.F. is slightly higher for a small current than for a larger one.

III.—Automatic Current-Regulator.

We think it possible that a neglect of the power that accumulators possess of drawing on a store of energy put i nto them in former chargings may have led experimenters to conclude that the normal efficiency of certain types of accumulators was greater than was really the case. To ascertain the *working efficiency* of the accumulators we were testing, it was clear that they would have to be charged and discharged alternately with a definite charging and a definite discharging current continuously for a much longer period than five days. And as this would be a very laborious operation if the current had to be kept constant day and night during this period by hand regulation, we proceeded to construct the automatic current-regulating device shown in Fig. 5.

A is a set of five accumulators under test, where B is a totally independent set of four used to provide the power for working the current-regulator. C is a platinoid strip of sufficiently large cross section and surface that no appreciable change of resistance can take place by the largest current—10 amperes—that flows through it in these experiments. D is a permanent magnet motor, the rotation of which in either direction turns the brass roller, E F, very slowly in one direction or the other, the pinion and toothed wheel of the motor, combined with the small grooved pulley on the toothed wheel shaft and the much larger grooved pulley on the roller, causing the angular motion of the roller to be about 1-500th of the angular velocity of the armature of the permanent magnet motor. The brass roller, E F, is electrically divided into two halves by the ebonite disc, G, and little amalgamated discs at the ends of this roller turn with but little friction in mercury cups, H, I. Round each

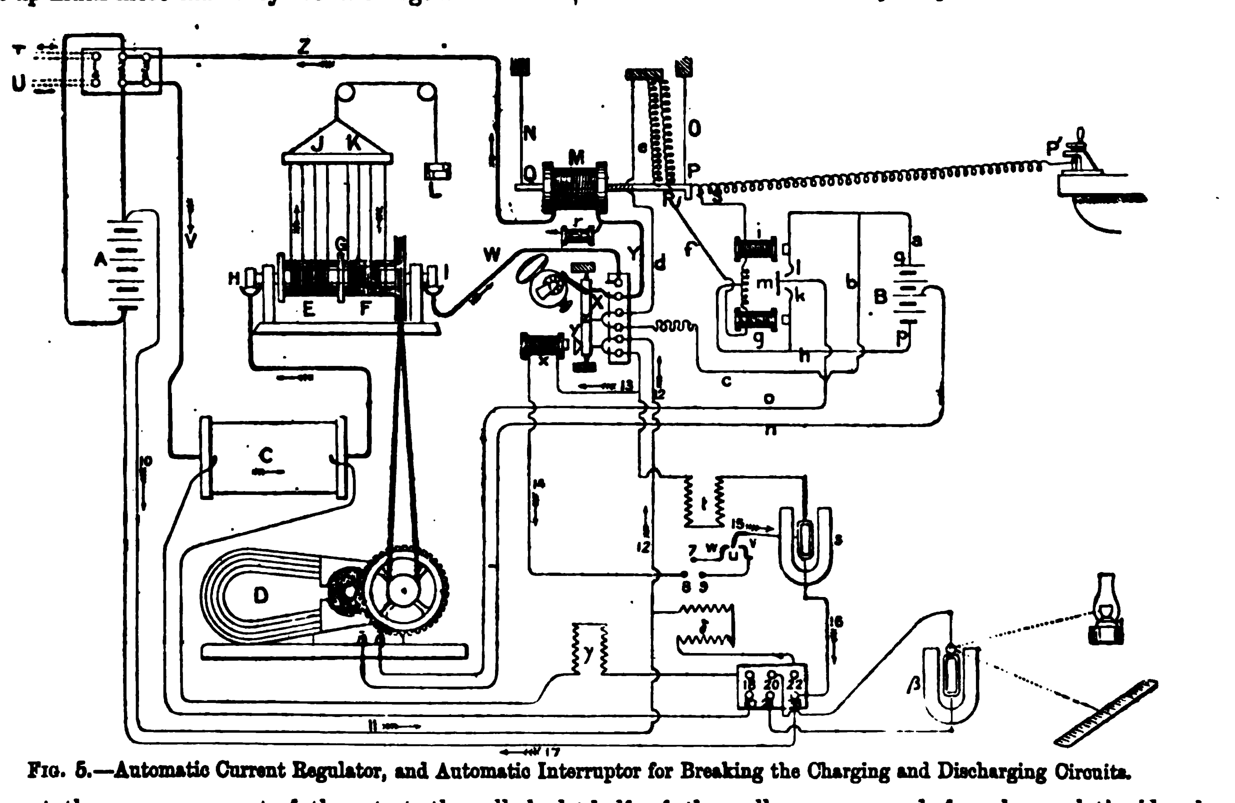


Fig. 5.—Automatic Current Regulator, and Automatic Interruptor for Breaking the Charging and Discharging Circuits.

half of the roller are wound four bare platinoid wires of No. 26 gauge, and each about 4½ft. long. Their lower ends are soldered to the brass roller, and their upper ends to the brass bar, J K, small spiral springs (not shown in the figure) being introduced to keep the wires taut. The rod, J K, is held up by a cord which passes over two pulleys, and to the end of which is attached the weight, L. An electric current entering at H follows the path, H,E,J,K,F,I, the path being longer or shorter depending on the amount of the platinoid wires wound on the two halves of the brass roller. M is a solenoid, being, in fact, the coil of an A. and P. ammeter, on the axis of which a rod, P Q, was very delicately poised by its being supported by four very fine wires of No. 40 gauge, and each about 1ft. long. Two of the wires, N, on a plane at right angles to the path, joined together where they were connected with the rod at Q, but spread out at the top, and similarly O consisted of two wires. Thus, while the rod, P Q, had great freedom of motion along its axis, it could not wobble sideways. This rod consisted of two pieces of brass at its ends, but the middle shaded portion was the well-annealed soft iron tubular core of the ammeter. A current passing round the coil, M, sucked in the core more or less against the pull of the antagonistic spiral spring, P P'. This spring was made of platinoid wire of No. 26 gauge, wound round a ⅜in. mandril, and when pulled out in position it had

cury cups 7 and 8, and when, on the P.D. at the terminals of the accumulators, A, reaching 2·4 volts per cell, the pointer, *u*, passes over and makes contact with *w*, an instantaneous small current is sent by the accumulators, A, through the electromagnet, *x*, which, attracting the armature, *y*, downwards, tilts the spindle, *z*, and thereby lifts X and the other two contact forks out of the three sets of mercury cups, thus breaking all the circuits. The tilting of the spindle, *z*, also brings a camel's hair brush into contact with the balance of a watch, and stops it at the moment the charging is completed.*

In discharging the cells, A, mercury cup 7 is connected to 9 instead of to 8. During the discharge the pointer, *u*, rests against *w*, and on the terminal P.D. of the cells falling to 1·6 volts per cell the pointer moves over, comes into contact with *v*, and an instantaneous current passes round the electromagnet, breaks all the circuits, and stops the watch. The course of this instantaneous current at the end of the charge and discharge is indicated by the arrows numbered consecutively 10, 11, 12, 13, 14, 15, 16, and 17.

To prevent any sluggishness in the action of this interruptor from a possible sticking of the pointer, *u*, against the contact-stops *v* or *w*, the pedestal supporting the set-up galvanometer, *s*, was kept in a constant state of slight vibration by the going of an American clock works that were placed on this pedestal.

V.—Ammeter and Voltmeter.

There remain only to be described the ammeter by means of which the current passing through the accumulators could be measured from time to time in order to see whether the automatic regulator was doing its duty, and the voltmeter for frequently measuring the P.D. at the terminals of the accumulators, A, under test. As the current had only to be very occasionally measured, one D'Arsonval galvanometer, β, was employed for both purposes. Its coil was wound with platinoid wire of 52 ohms resistance, and suspended in the way that has been already described,† which enables the deflection from one end of the scale to the other to be absolutely proportional to the current. The top suspension was a phosphor-bronze strip 1-1,000th inch thick, 12-1,000ths wide, and about 1¾in. long; while electric contact was maintained with the bottom of the coil by means of an extremely fine A. and P. spring, offering no appreciable torsional rigidity. The permanent magnets employed belonged to an old magneto machine, and into the cylindrical space between their poles, in which the Siemens armature formerly turned, was put a coil made of the right shape to suit the curved ends of the magnets without it being necessary to employ any soft iron pole-pieces. Experiment showed that the deflection right across a scale 2ft. 9in. long, the zero for no current being at one extreme end, was rigorously proportional to the current—a result which, as has been already pointed out, is very far from being obtained with D'Arsonval galvanometers as usually constructed.

When it was desired to measure the current passing through the accumulators, A, a rocking switch was turned so as to connect mercury cup 18 to 20 and 19 to 21; whereas when it was the P.D. at the terminals of the accumulators that was to be measured, the rocking switch was turned so as to connect mercury cup 20 to 23 and 21 to 22. In the former case, with a resistance of 264 ohms on the resistance-box γ, a current of 10 amperes passing through the cells and platinoid strip, C, produced a deflection of 500 scale divisions, or 50 divisions per ampere; while, with a resistance of 71,570 ohms in the resistance-box δ, a P.D. of 10 volts at the terminals of the five accumulators, A, under test produced the same deflection; so that 50 divisions corresponded then with one volt.

VI.—Results Obtained with Automatic Apparatus.

Many preliminary experiments having been made with the automatic apparatus, we succeeded in making it work quite satisfactorily by the beginning of May, 1889, and it was adjusted to charge five accumulators, A (Fig. 5), with a steady current of nine amperes until the P.D. reached 2·4 volts per cell, and to discharge them with a steady current of 10 amperes until the P.D. fell to 1·6 volts per cell. After 12 days and night had been spent in continuous charging and discharging, the cells reached a normal state, the time rise of P.D. in charging and the time fall in discharging being at length repeated over and over again, so that when the time curves were drawn for the successive charges they exactly coincided, and so for the discharge curves.

Fig. 6.

The areas of these curves measured, of course, from the zero of P.D., which is much below the figure as here drawn, may thus be said to give the "working watt-hours" for charge and for discharge when the charge and discharge are effected between limits of 1·6 and 2·4 volts per cell. Fig. 6 shows the discharge curves obtained on May 16th, 17th, 18th, and 19th, the points for each of the discharges being indicated by points differently marked as stated on the figure; and Fig. 7 shows the intermediate charge curves obtained on May 17th, 18th, and 19th. Integrating these curves, we find:

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
115	221·8	117	256·2	98·3	86·5

Soon after this very concordant set of results was obtained, the time of charging, which had remained steadily at 13 hours from the commencement of May, began to increase to 15¼ hours, while the time of discharge only increased half an hour—that is, to about 12 hours. At first we thought that we had been trying to charge the cells too much, so we stopped the charging when the P.D. per cell rose to 2·35 volts; but the time of charging still continued to increase, until at last it rose to 24 hours, the time of discharge still remaining about 12 hours. On again reducing

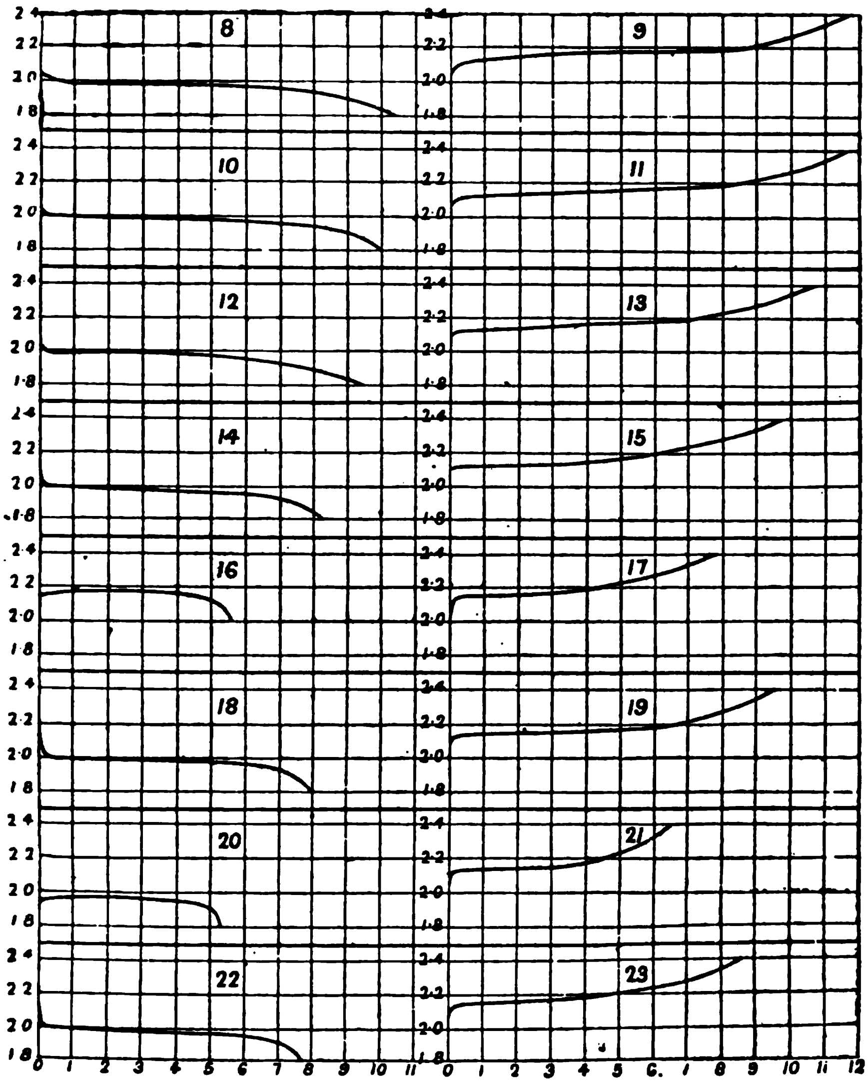
Fig. 7.

the P.D. limit on charging, the P.D. per cell now refusing to rise to 2·35 volts, both the times of charging and discharging became very irregular, and at length the time of charging suddenly fell to 10 hours and the time of discharging to six. On carefully examining the plates, they were found to have badly scaled and to have suddenly become partially short-circuited; they were therefore carefully scraped, and the mud allowed to settle at the bottom, where, in consequence of the special construction of the 1888 cell, it could remain without short-circuiting the plates. Only a few plugs fell out in this operation. This sediment was afterwards weighed and analysed, showing a composition that will be referred to in Section VIII., on the Chemical Action.

* As it was undesirable to risk an expensive watch, we purchased one of the watches that could be then obtained in St. Paul's-churchyard for 3s. 5½d. The watch was very substantial, had a very strong hair spring, which could not be easily damaged, and was an excellent time keeper—far superior to many watches of a far more expensive character.

† See paper on "Galvanometers," *Phil. Mag.*, July 1890.

We now concluded that we had been running the cells too low, and we therefore decided to stop the discharge



when the P.D. per cell fell to 1·8 volts, retaining the higher limit of 2·4 volts per cell to limit the charge. It is interesting to notice that Dr. Louis Duncan and Mr. H. Wiegand, in their paper on "The Inherent Defects of Lead

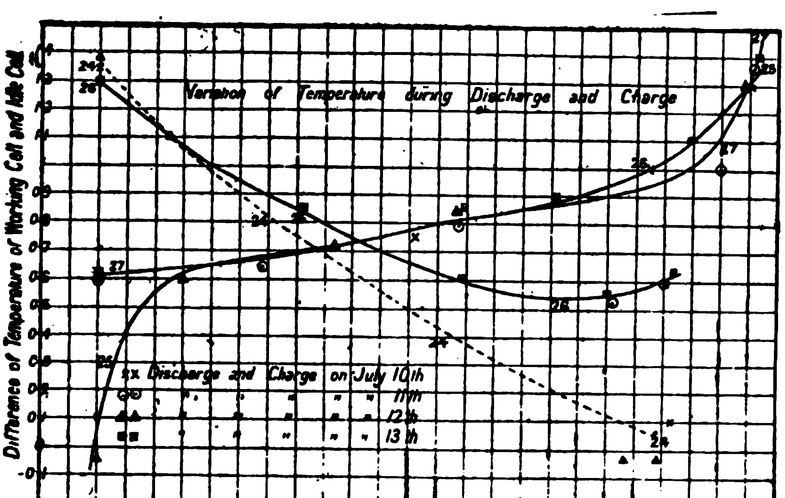


FIG. 8.

Batteries," read before the American Institute of Electrical Engineers, and which we saw for the first time at the end of June, reprinted in the *Electrical World*, come to exactly the same conclusion—that the discharge should be terminated at 1·8 volts per cell, otherwise there is a formation of white lead sulphate and a rapid depreciation of the cell. From what we have since seen, we think that the discharge should be stopped even still sooner—when the P.D. per cell has reached 1·9, or 1·85 volts at the lowest.

We therefore adjusted the automatic interruptor to stop the discharge when the P.D. per cell was 1·8 volts, and the immediate result of this was to bring the time of charging up to 12¼ hours, and to bring up the time of discharging to 10½ hours.

After continuing the charging and discharging continuously day and night for 13 days, the cells reached a perfectly steady state. Fig. 8 shows the time curve of P.D. per cell in the discharges finished in the early morning of June 19th, recommenced in the night of June 19th, and again commenced late on June 20th, all the three discharges being so precisely similar that they can be represented by one curve; and, similarly, Fig. 9 shows the intermediate charging curves on June 18th, 19th, and 20th, which were also exactly the same. The times of the three discharges and of the three charges were, respectively, in hours and minutes—

TIMES OF SUCCESSIVE

Discharges.	Charges.
10h. 10m.	11h. 38m.
10h. 10m.	11h. 37m.
10h. 11m.	11h. 37m.

showing to what an absolutely definite state cells arrive after a definite cycle of charge and discharge between fixed limits has been repeated continuously without interruption for some weeks.

Integrating these curves, we find—

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
101·9 ...	201·7	104·5	230·7	97·2 ...	87·4

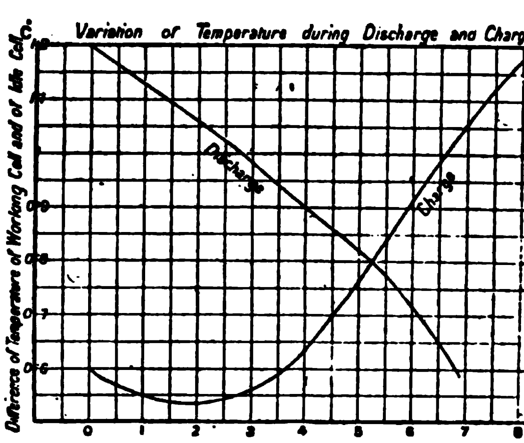


FIG. 9.

The numbers contained in this last table may probably be considered as giving the steady working values for this size and type of cell. 230·7 watt-hours are equivalent to 612,200 foot-pounds, and as the positive and negative plates of one cell weigh 28lb. 10oz, the working storage capacity is 21,380 foot-pounds per pound of plate.

(To be continued.)

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We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

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BRUSH v. KING, BROWN.

Another judgment; another bill of costs, and the close of another chapter of litigation is to be found in the judgment given at Edinburgh in this case. Briefly put, the Brush claim to compound winding is held to be invalid. King, Brown, and Co. can go on making their machines, and the Brush Co. are mulcted in expenses. Mr. Varley is held to have anticipated Brush. It is useless to be wise after the event, but many people will wonder what will be the exact effect of this judgment. Most makers, disgusted with litigation in any shape or form, agreed to arrange matters, feeling that it would cost less in the long run than would the lawyers.

DEATHS FROM ELECTRIC CURRENTS.

The world of opposition has from time to time been moved to its very centre by the records of accidents from electric currents. From the time of the accident on board the Emperor of Russia's yacht to the present, those who oppose the introduction of electrical energy have used every effort to imbue the minds of the multitude with the idea that electricity is fearfully and wonderfully dangerous. In order to make a greater impression, some of the daily papers inserted telegrams and paragraphs from their correspondents, especially from America, till readers began to believe that the use of electricity led almost to the decimation of the population. Then we heard of walking sticks, umbrella handles, and life preservers that were to contain electrical energy in some form or other that should prove as disastrous to the human race as snake bites or mountain dew. We endeavoured to point out that most of the accidents were preventable, that in many instances the imagination replaced fact, and that duly installed electric energy should be safer than moving mill wheels, or gas pipes. Lately there has been a lull in sensational paragraphs, the necessary material not being to hand, probably from greater care being taken by those engaged in electrical work.

There has, however, been just issued a parliamentary paper, containing a copy of the correspondence between the Foreign Office and the Board of Trade with reference to deaths from electric currents in the United States. It seems that the American Government could not furnish a list, because there was no list compiled, but the efforts of the Foreign Office to get at facts were rewarded in a small measure by obtaining an authoritative list of deaths from electricity in New York City from January 1, 1887, to May 15, 1890. This list is gruesome enough in all conscience, and its discussion is unpleasant, but it is necessary to consider the cases to see how far our contention is correct, that in the majority of cases accident, and especially fatal accident, was preventable.

force for members of the Institution. Some more thoughtful, more free, or possibly better sailors than others, had arranged to go down by boat from London to Edinburgh on the Saturday and arrived some time in the Sunday afternoon. As the sea was smooth and the weather comparatively fine, this was a pleasant and healthy interlude. The great railways run very fast trains to the North, and one service, the 10 o'clock from King's Cross, does the distance in 8½ hours. Fortunately, the very bad weather that has prevailed for so long lifted, and Edinburgh looked very pleasant, clean, and fresh after the long journey. Most of the members took a short look round the exhibition on Monday evening for an hour or so after the dinner on arrival.

On the Tuesday morning the members assembled at half-past ten in the lecture hall to hear Dr. Walmsley's paper, written at the request of the council, and describing or indicating the more noticeable features of the exhibition, but mainly the electrical ones, so that the members might have a foretaste and a critical *menu* of the good things they will see and admire. The members of the council who were present included the president (Dr. Hopkinson), Sir Henry Mance, C.I.E., Mr. Preece, Mr. Spagnoletti, Mr. Kapp, Prof. Perry, and Mr. Nalder. Mr. Webb, the secretary, was very largely aided in his engagements by Mr. A. R. Bennett, who has been largely instrumental in the arrangement of the electrical part of the exhibition. Lord Bury was also present, and the attendance of M. Hospitalier and his colleague, M. G. Roux, from Paris, was much appreciated. Dr. Hopkinson, who presided, opened the meeting, saying that although the time was not yet for returning thanks to the executive of the exhibition, he thought they would all feel grateful for the trouble they had taken in arranging for the Institution. The exhibition, he said, was a great deal better and more interesting than he had thought. He had to make the announcement that Sir Archibald Campbell had given an invitation to the members to visit his private works and laboratory, which were extremely interesting: one thing specially so being the largest influence machine in the world, a machine that had been only recently constructed. Mr. J. B. Johnstone, of 8, Dalousie-terrace, was also wishing to show members experiments which he had mentioned in his recently published book.

Dr. Walmsley's paper, which we shall give in due course, dealt first with the historically interesting part of the exhibition, then with the electric lighting arrangements, the prime movers, the transmission of power, the instruments, and the telephones. Mr. Preece, in commenting upon the paper, mentioned the interesting fact that there are at the present time 16 multiplex telegraph circuits at work in Great Britain on Delaney's system. He had noticed the instruments in the Philadelphia Exhibition of 1884, had tried it, adopted it, the Post Office had taken it in hand and had found or made it a real practical instrument, while the Americans themselves have not as yet used it at all.

Mr. A. R. Bennett next read a paper in which he dealt with some little noticed or little understood electrical reactions in telegraph and telephone wires themselves. Many curious noises are heard in telephone lines: occasionally he had tried and found deflections able to be registered on a sensitive galvanometer. He had resolved to investigate these actions and the origin of these foreign currents. The outcome of his investigations given in the paper were: first, that the introduction of copper wires working in conjunction with or near iron wires, as is now often the case all over England, produced in wet or damp weather an electric couple or cell when the insulators became covered with a film of water. The deflection in wet weather, or when the insulators were wetted in the test-room, was positive for copper and negative for the iron wire, the latter being much the less. These effects he traced to the action of the damp upon both the iron line wire and the iron bolts of the insulators, the less deflection of the iron being due to the partial earthing of these by the wet wood of the poles. He also mentioned that the charge necessary for the wires was greater in wet weather, due to the extension, as it were, of the capacity of the wire to the wet film. He also found he could polarise the wire and the supposed electric couple, and even obtain a back current, making the copper and iron couple act as a secondary battery. He also pointed out other effects.

Mr. Preece said the phenomena were, he thought, indicated in Fleeming Jenkin's book, where it was shown that in wet weather voltaic currents were formed due to the action of the water. In practice these were not any serious detriment. He had spent whole nights listening to the sounds in the line wires through a telephone, some like a child crying, some like a young bird in its nest. He thought possibly these might be sometimes attributed to the swaying of the line across the field of the earth's magnetism. Some were due to atmospheric electricity. Foreign currents due to the induction from electric stations were a cause of considerable difficulty. The Deptford station had given the Post Office very evident symptoms of its presence, and the influence had even been felt in Paris. At Blackpool, when the current for the tramway rose and fell, the telegraph felt the effect. At Gretna he had discovered distinct traces of currents 45 miles away. Electric discoveries and applications were increasing, and this led to greater notice being taken of these smaller interferences, electric works were being established, and at the same time instruments were more delicate. The current distinctly heard in a telephone was to be represented in amperes by thirteen oughts with a one at the end. Greater delicacy has shown currents which may, in the future, cause trouble, but have not done so as yet. Mr. Heaviside mentioned that he had used the effect described to clean the insulators. By substituting copper wire for iron wire the deposit of oxide could be gradually cleaned off, and a source of loss of insulation removed. Mr. Bennett, in replying, thought the increased effect now noticed was due to the increase of copper lines all over the country. As to the swaying he had made experiments, and succeeded in obtaining a rhythmical deflection by the swaying of the line across the earth's field. An American gentleman who lately visited him had said they never attempted to use the telephones after nine at night on account of the electric light, which started then. The telephone communication had been much deteriorated by the increase of electric roads, and considerable litigation was in progress. The telephone companies wished the tramway companies to run metallic circuits, and the tramway companies desired the telephone companies to do so. Which would be decided he did not know, but this was the great question which is being debated in the United States at the present time.

After papers it was announced that Dr. Walmsley and Mr. A. R. Bennett would constitute themselves personal conductors, and take the members in parties round to the most interesting exhibits after lunch. In the afternoon, therefore, the members passed in a busy questioning and listening body round the machinery department under the guidance of these two gentlemen.

The exhibition has been very well and carefully laid out, and must be concluded to be a distinct

success. It was thought to be some distance from Edinburgh, but in reality it is only just on the outskirts, and trams, electric launches, and the railway, of which there is a special station in the exhibition, run continually. Coming from the beautiful city, with its clean stone buildings and streets, its imposing University fronts and the gardens before them, the Castle massively topping the rising hill, one sees the broken sky line of hill and dell on every side. From the exhibition ground, at Merchiston, one has the lovely Pentland Hills as a background to the buildings, posts, and walks of the exhibition. The buildings are handsome in their way and are very well arranged. The grounds are well laid out and are filled to overflowing with extra shows. Here the sliding railway, there the Japanese village; again the electric launches, an ingenious ship railway (the ship floating on indiarubber bags), the electric railway, besides panoramas, switchbacks, and the *hoc genus omnes* of exhibitions. The machinery hall holds a fine position in the centre, and the driving and lighting machinery have the position of honour in full view of every visitor.

CORRESPONDENCE.

FIRE OFFICE RULES.

To the Editor of the Electrical Engineer.

Sir,—I venture to trespass on your valuable space in reference to a matter which is engaging a considerable amount of attention among electrical contractors at the present time—viz., fire office rules.

Formerly most contractors carried out their work as nearly as possible in accordance with the Phœnix rules, but now every fire office has a special set of rules for electric lighting on its own account. This was of course to be expected, as competition among insurance offices is as keen as in any other business.

What is the electrical contractor to do? In an important installation the building and contents are often insured in three or four leading offices, all of whom ask if the work has been carried out in accordance with their particular rules, and how can this possibly be done when the rules vary in important respects?

It seems to me that the sole remedy is for the electrical contractor to work carefully in accordance with the rules laid down by the Institution of Electrical Engineers. If these rules are considered insufficient in any particular respects contractors will soon hear of it, and where there is any consensus of opinion a report should be made to the Institution, and a periodical revision of the rules undertaken by a committee.

This, I believe, would do away with the present hopeless condition of affairs, when a surveyor from one leading office expresses great satisfaction with work one day, and the next day a surveyor from another equally important office swoops down and harrasses the contractor by demanding alterations which can best be described by F A D in capitals.

31, King-street, W.C., July 27. John B. Verity.

THE LINEFF TRAMWAY SYSTEM.

To the Editor of the Electrical Engineer.

Sir,—In your issue of 11th inst., Mr. Holroyd Smith describes what he calls his "snake trick," and winds up his letter by saying "after going into the matter pretty freely at the time, I came to the conclusion that the 'pros' did not equal the 'cons,' and my drawings and models have all been packed away and labelled 'Historic.'"

I was prepared to hear the usual cry "I did it before you." I do not wish to throw any doubt on Mr. Holroyd Smith's statement, and am, therefore, quite ready to admit the possibility of the existence of such things in his "Historic" collection, but that he did not attach much importance to the idea is evident from the fact that no trace of it is to be found in the numerous Blue-books relating to his inventions.

Mr. Holroyd Smith is good enough to offer some advice as to avoiding certain difficulties which he has encountered in working on a system which in the end turns out to be only good enough to be discarded. I am much touched by this mark of goodwill, but as my conductor answers its purpose admirably, while the "snake trick," after getting as far as the model stage, is consigned to oblivion even by its inventor, I think I am in a better position to offer my advice to him. Apparently Mr. Holroyd Smith also thinks there is something in this, for he says: "I am therefore curious to know what Mr. Lineff's method will be."

However, I am not inclined to go into this, but I can certainly tell Mr. Holroyd Smith why his trick will not answer. The spiral he adopts is about the worst possible form to convey the magnetic lines. Talk about lock stitches and chain stitches. The difficulty in Mr. Holroyd Smith's arrangement is to catch them, for they are sure to exist in all directions where they are not wanted, and to be conspicuous by their absence where they could do useful work. And this scarcity of "stitches" is the real reason that the "snake" had to be considered "historic."

The longitudinal sketch again proves that Mr. Holroyd Smith has very little idea of what really takes place under the surface rail. The spiral can never be attracted in the manner indicated. It will either make contact at A A or

both at A A, B B, and the power required to effect the attraction will be enormous.

With regard to what Mr. Holroyd Smith takes for pins for hauling purposes, his remarks would certainly have some point if this is what they were. As, however, they happen to be wire brushes, I may be excused if I do not feel any great amount of gratitude for his suggestion.

In conclusion, I may say that there is no "trick" whatever about my magnetic conductor. It is the result of a great deal of patient and painstaking work, and it took me six months to arrange my rails so as to reduce the current necessary to raise my conductor from six to ·25 amperes, which it now requires.—Yours, etc.,

A. Lineff.

11, Queen Victoria-street, London, E.C., July 16.

ACCUMULATOR TENDERS FOR TRAMWAY WORK.

To the Editor of The Electrical Engineer.

Sir,—My attention has been drawn to a paragraph in your impression of the 11th inst., in reference to accumulator tenders, wherein you say that "M. Paul Gadot is advocating the use of auxiliary cars for street tramways, to go in front of the cars and carry the accumulators, the motor being on the tramcar itself." As you rightly observe, this method was devised and patented by me. May I ask you to be good enough to let me know the source of your information. M. P. Gadot is an absolute stranger to me, and why he should advocate my system, I am at a loss to conceive. As regards the present position of this method of using accumulators for tramway work, I can only say that, so far as practical development is concerned, nothing has been done, but in the near future, when the adoption of electricity as a motive power will be an accomplished fact, I am convinced that the system identified with my name will be an important, if not an absolutely necessary, factor.

You are at liberty to publish this letter, should you think proper; meanwhile I should be glad of the information I ask.—Yours, etc., W. D. Sandwell,

Victor-road, Holloway, N., 12th July, 1890.

THE EDINBURGH EXHIBITION.—XI.

At stand 59a, Machinery Hall, Messrs. Priestman Bros., Limited, of Holderness Foundry, Hull, also of London and Glasgow, have an interesting exhibit, comprising some specimens of their patent oil engines shown in motion

driving electric lighting plant. These engines, which are now becoming well known and which have been much improved of late, are examples of one of the latest and most successful methods of producing motive power from so easily obtained a material as the common mineral oils of commerce, such as ordinary petroleum, paraffin, etc., a supply of which can be had in almost every town or village throughout the world. This is an advantage which cannot be over-estimated in places where coal for steam engines or coal gas is not available or is expensive. A further important feature is the use in the engines of the ordinary lamp oils, with which there is no danger either from ignition or otherwise, in distinction to the spirit such as benzoline, naphtha, etc., which is used in some other engines, and as to which there are certain restrictions. The method by which the motive power is produced is briefly as follows: The oil is stored in a small tank from which it is forced by air pressure into a heated chamber, which it enters in the form of a spray; the heat here converts the spray into a vapour or gas. This is then drawn into the cylinder, together with the requisite quantity of air to form a combustible charge, by the action of the piston in its forward stroke, and after compression by the piston upon its return stroke is ignited by an electric spark. After the explosion the exhaust is allowed to escape from the cylinder through the valve, and passes first through the jacket of the vaporising chamber, for the purpose of heating the incoming charge, and thence through the exhaust pipe into the open

Priestman's Oil Engine.

air. The oil which is used in this way is almost entirely consumed there, the waste gases passing away in the exhaust, which consists of a thin vapour. Another point worthy of mention is the absence of carbon deposit in the cylinder, due, firstly, to the complete combustion that takes place, and also to the fact that no lubricating oil is needed in the cylinder, the necessary lubrication being done by the oil vapour during action. The electric spark for igniting the charge is supplied from a small primary battery of the single-fluid type, which is very simple and easily understood; but in order to further simplify this the makers have devised an arrangement by which a small storage cell can be used in place of the battery, and we were told that by this arrangement it is possible to work the engine for three months without recharging the cell. In cases where the engines are used for driving electric lighting installations in which accumulators are employed, connections can be taken direct from them if thought desirable, entirely preventing any risk of failure.

The exhibits comprise one 5 h.p. nominal Priestman's patent oil engine, horizontal type, fitted complete with flywheel, oil-tank, air pump vaporiser, and all details required for the preparation of combustible charge. Water pump for cooling cylinder is also fitted, and separate water-tanks fixed to show all that is necessary for the proper working of the engine. In this engine, as, in fact, in all engines of the horizontal type, the design and construction make the whole very compact. The oil-tank, vaporiser, and other details for the preparation of the oil vapour, are fitted inside the bedplate of the engine, and secured to a cast-iron soleplate, upon which the bedplate is mounted. The soleplate extends entirely over the bottom of bedplate, and thus makes the fixing of the engine upon foundations very simple. The bedplate has doors placed in a convenient position, so that the parts in the interior can be easily examined, and through these doors any of the parts may be taken out very easily.

Exhibit No. 2 consists of one 2 h.p. nominal Priestman's patent oil engine, which is also complete with flywheel and all details precisely as described in the 5 h.p. referred to above.

Both engines can be seen in motion, and are employed to drive an electric light installation for lighting the stand. The power is taken from the engines by means of belts working upon the flywheels to a countershaft placed at the back of the stand, which is so arranged that either one or both engines may be used for working the dynamo, which is driven by a belt from the countershaft.

The electrical installation comprises a small Tyne dynamo (made by Ernest Scott and Co., Newcastle-upon-Tyne), a set of accumulators or storage cells, and an arrangement of fittings, lamps, measuring instruments, etc., to make the whole complete.

The above exhibits combined together are intended to represent a complete electric lighting plant and installation as worked by Priestman's oil engine, such as are now being used considerably, and are very suitable for mansions, private houses, mills, factories, central stations, etc.

Another, and perhaps the most important, exhibit which Messrs. Priestman Bros. have, is a 9 h.p. nominal Priestman oil engine, which is placed in a separate building near the Venetian glass factory, and is used for driving the dynamo, etc., for the search-light in tower at main entrance. The engine is of the horizontal type, and is complete in all respects as those previously described, and is so situated that to those who are interested every opportunity is given them of making a thorough examination of all the parts. This plant, being placed as it is away from all other sources of power, and without either steam, gas, or water supply, forms a perfect illustration of the great suitability of the oil engine for isolated places, as by its use electric light or power can be easily generated and conveyed to required positions. This will be of special advantage for lighthouses and similar stations, particularly as the oil used in the engines is that which is used for the lamps, etc. As an example of their utility in this latter respect, we are informed that Messrs. Priestman Bros. have some of their engines put to work at Carswell Lighthouse, near Stranraer, and owing to the successful results of the severe tests to which they were submitted, the Northern Lighthouse Board have placed orders for further engines of this type for other stations.

The advantages possessed by Priestman's oil engine for other purposes than those already referred to is evident

Secondary closed Heat applied.

Temperature of the core	100° C.
Primary E.M.F.	89·3 volts.
Secondary E.M.F.	11·9 „
Ratio $\frac{89·3}{11·9}$	8·1
Secondary current..............	2·0 amperes.

Secondary closed Core heated.

Temperature of core	270° C.
Primary E.M.F.	95·7 volts.
Secondary E.M.F.	13·4 „
Ratio $\frac{95·7}{13·4}$	7·1
Secondary current	2·4

TABLE I.

—	Temp.	Primary E.M.F.	Primary watts.	Secondary watts.
2. Secondary open, no heat applied to core..............	97·5°C.	75·6	87·	0·0
4. Secondary open, heat applied to core.................	300° C.	99·4	88·	0·0
5. Secondary closed, no heat applied to core..............	100° C.	89·3	139·	24·
6. Secondary closed, heat applied to core..............	270° C.	95·7	129·	36·7

TABLE II.

Temp.	Loss in core.	Primary watts.	Secondary watts.
2. 97·5° C.	122	122	0·0
4. 300° C.	72·	72	0·0
270° C.	79 (Estim.)	79	0·0 { Corrected for rests of sec.
5. 99° C.	117	131	24
6. 270° C.	80	116·7	36·7

Data are presented in the latter part of this paper showing that it is correct to assume for small ranges that the loss in the core is proportional to the square of the primary E.M.F. We can therefore deduce from Table I. the results that would have been obtained with 90 volts as the primary E.M.F. for the four experiments.

Primary, 90 volts; 120 reversals per second.

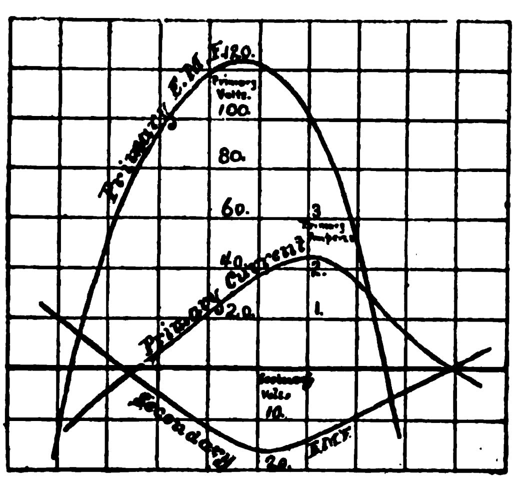

FIG. 5

The figures in Table II. show clearly that the loss in the core is greatly diminished when its temperature is elevated—*i.e.*, when heat is applied—and that the loss in the core is practically independent of the output. The results indicate that with the secondary open, and the primary at a difference of potential of 90 volts without heat applied, the core came to a temperature of 97deg. C., and dissipated 122 watts; then by the application of heat with the Bunsen burner, as indicated in Fig. 1, the temperature of the core was raised to 300deg. C., and was found to take up 72 watts. Now, if we assume the changes in watts dissipated in the core to be approximately proportional to the changes in temperature that produced the same, then we see by estimation that 79 watts would have been dissipated by the core at 270deg.C., while 80 watts were found to have been dissipated by it at that temperature when the secondary was closed and gave an output of 32 watts.

It is perfectly plain, therefore, why we can close the secondary, take from it 32 watts, elevate the temperature of the core 170deg.C., and have the primary take up five watts less than when the secondary was open, and the core at the lower temperature.

Since the effect is due only to the fact that the core takes up much less energy at higher than at lower temperature, and since the core can dissipate energy through Foucault current and hysteresis phenomena only, it is due to a decrease of the total energy dissipated through changes in the above phenomena.

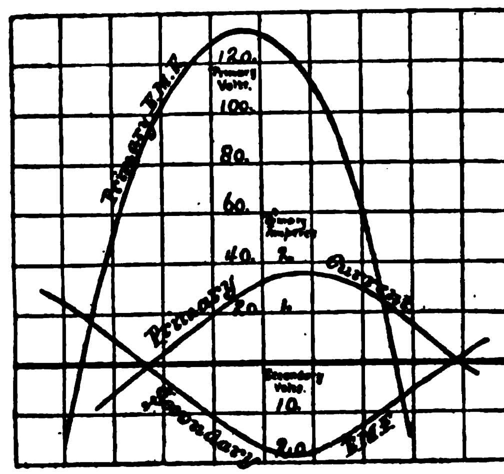

FIG. 6

A rise of temperature in the core will increase its specific resistance, and therefore diminish the energy dissipated by Foucault currents. For decided degrees of magnetism it is known that the permeability of iron increases when it undergoes a rise of temperature. It was thought probable, therefore, that the energy dissipated per cycle of magnetisation and demagnetisation would be decreased with an increase of temperature.

Experiments were made in the Physical Laboratory of Cornell University by Mr. Arthur Herschel on the hysteresis at high temperature of a cast-iron ring, 12·3 cms. in diameter, that furnished a closed magnetic circuit, the length of which was 38·5 cms. The ring was wound with 80 turns of No. 8 wire cable that had a mica insulation. The highest temperature to which the ring was subjected was 360deg. C.

One interesting thing about these results is that for degrees of magnetisation below 2,000 lines per square cm., the variation of temperature below 360deg. C. does not change the magnetic character of the iron by an observable amount. Now, if wrought iron behaves in a similar manner then the decrease of energy dissipated in the apparatus of Mr. Marks was not due wholly, nor in part, to a diminution in the hysteresis of the iron. It was, therefore, due entirely to the diminution in Foucault currents, caused by the change of the resistance of the iron. A liberal estimate for the hysteresis of the core is 20 watts, whence the Foucault energy dissipated by the core at 100deg. C. and 90 volts was 102 watts, and at 270deg. C. and 90 volts it was 60 watts.

(To be continued.)

DRILLS FOR BORING HOLES OF SQUARE AND OTHER SHAPES.

There are being exhibited at 2, New Broad-street, E.C., by the Ainley-Oakes Square Drill Company, Limited, of 58, Lombard-street, E.C., a couple of drilling machines which will be found of great utility by electrical engineers. The first of these is the Ainley-Oakes square drilling machine, which will drill holes either round or square. It is similar in appearance to an ordinary drilling machine, and the driving of the spindle and the feed downwards is the same. The spindle, however, consists of three concentric parts: firstly, an outer sleeve carrying a bevel wheel

and driving the intermediate sleeve by means of a key way and feather; secondly, an intermediate spindle having a set of cams upon each of its ends; and, thirdly, an inner spindle carrying the tool, which cuts with one edge only. The second machine, the Tyler-Ellis, is a development of this, and will cut square, hexagonal, octagonal, or any other shape of hole, and this we illustrate in Fig. 1. A side section of this machine is shown in Fig. 2, and a plan in Fig. 3.

FIG. 1.

FIG. 2.

FIG. 4.

FIG. 3.

In the first-mentioned machine the guides for the spindle consist of flat plates of very hard steel, made in halves and adjustable. There are four of these, the two inner having round holes, and engaging with the circular part of the spindle for drilling round holes. These are run back when the machine is drilling square holes, and the upper and lower plates, which have square holes in them, are screwed up so as to engage with the cams to give the required motion to the spindle. The pair of cams with which the square plates engage is determined by the position of the intermediate spindle, which is capable of being raised or lowered by a hand lever and lifting gear. This lever works in a quadrant, and is provided with five notches, corresponding with the five sizes of holes which the machine can drill. The cams are set out as follows: A square hole is described equal to the hole to be drilled. From any point in one side of the square an arc of a circle is described, with a radius equal to the side of the square. From the points where this arc intersects the sides of the square, other equal arcs are described completing the curve triangle. The square in which the cam is to revolve is now drawn and from each of the vertices of the curve triangle two arcs are described, which complete the figure. The cams in question are illustrated in Fig. 4.

In the Tyler-Ellis machine, as illustrated, the spindle moves about the centre of a ball joint, and by lowering the inner spindle, which carries the tool, the size of the hole drilled can be varied. By the use of a cranked tool in the holder, the outsides of objects can be shaped and finished.

The machines will effect a very considerable saving in labour, and the advantages of being able to bore any shape of hole at one operation will be evident to makers of electrical machinery.

SHAPING FILAMENTS OF INCANDESCENT LAMPS.

When the looped-shaped filaments of incandescent lamps are straightened by a weight during the period in which the air in the bulb is exhausted the removal of the weight is found to be a rather delicate operation. In straightening the filaments in this manner it has ordinarily been found necessary to attach to each lamp bulb an exhaust tube longer than usual. After the operation of exhausting has been completed this tube is first sealed some distance from the globe, and the lamp removed from the pump. By manipulating the lamp the weight is unhooked from the loop and dropped into the tube, which is then sealed off from the lamp. The accompanying diagram illustrates an improved method of handling the weight by

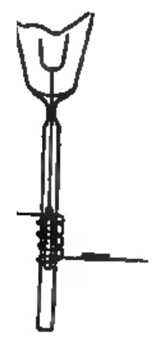

FIG. 1. FIG. 2.

magnetism. A glance at Figs. 1 and 2 will show the simplicity of the operation. The small weight shown in the tube and hung on the filament is made of iron or other magnetic material. By this construction it is only necessary to use a magnet as shown in Fig. 1, or a solenoid as indicated in Fig. 2, and the weight may be manipulated as desired. It is evident, too, that the magnetism of the solenoid or permanent magnet may be employed to increase or diminish the strain or pull on the weight. This ensures a delicacy of adjustment otherwise unattainable. This method of weight manipulation in the above-mentioned process is the invention of R. N. Dyer, of New York.

LEGAL INTELLIGENCE.

ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION v. KING, BROWN, AND CO.

Judgment was given by the First Division of the Court of Session on Wednesday in the reclaiming note against a judgment of Lord Trayner, reducing, at the instance of King, Brown, and Co., Edinburgh, the patent of 1878 of the Brush Corporation for series-shunt or compound-wound dynamo machines on the ground that that patent had been anticipated by Varley's patent of 1876, both by prior publication and by prior use.

The Court adhered to the judgment of the Lord Ordinary, and found the Brush Corporation liable in expenses.

Lord M'Laren, who read the judgment of the Court, said the defenders, the Brush Electric Light Corporation, claim under their patent the exclusive privilege of making dynamo-electric machines in which the electromagnets are of the type known as "compound-wound" magnets, also known as the "series-shunt" type. The pursuers, King, Brown, and Co., are makers of "compound-wound" dynamos, and their right to make such machines having been extrajudicially challenged they have brought this action to have the defendants' patent reduced and declared void on various grounds, the chief objection being that the invention of compound winding was previously discovered and made known by Mr. Varley, and consequently that Mr. Brush, or his assignees, are not in the position of being the "first and true inventors" of this valuable electric appliance. There can be no doubt that the holders of Brush's patent claim compound winding as an essential feature of their machine, and accordingly, if this claim be ill-founded, the patent must fall. The argument was directed mainly to the question of the anticipation of the Brush system of compound winding by Mr. Varley, and I shall consider this subject in the first place, touching afterwards on the objections to Brush's specification, which are of a technical character. In order to make my observations intelligible, I must begin by stating in what compound wiring consists. When the armature of the electromagnet is attached to an axle, so as to be capable of rotating in the magnetic field, the armature tends to place itself in a symmetrical position with reference to the poles of the magnet, and if force is applied to turn the armature on its axis, the movement of rotation is resisted by the forces in the magnetic field. The energy expended by the steam power, or whatever power is employed, to turn the armature against the resistance of the magnetic field is then converted into current electricity, and the current being carried through the revolving axis by insulating wires is given off by an appliance termed the commutator, passing thence into a conducting wire, and is then ready to be used for electric lighting, or any other purpose of utility to which it is capable of being applied. In the rudimentary form of the dynamo machine, I understand that the excitation of the electromagnets was maintained from a separate or, as it is termed, an external source, generally a battery of some kind. The first improvement consisted in winding one of the conducting wires round the electromagnets, the continuation of this wire being led into the external or working circuit. In this way the current flowing from the dynamo was made to maintain the magnetism of the electromagnets as a part of the work which it had to perform. This is known as series winding, because there is one continuous current which is only partly used in maintaining the magnetism. The next improvement consisted in dividing the current as it flowed from the commutators into two partial currents. In this system the wire is bifurcated; one branch is wound round the electromagnets and is returned to the opposite poles of the commutator. The second branch wire is employed for lighting or external work of some kind, and is reunited to the first branch wire near where it meets the commutator at the opposite pole. This is the form known as the shunt-winding system, or shunt machine. The invention of compound winding, with which we are here concerned, consists in, I will not say a combination of the two methods, but with the addition of the shunt and the series method. The wire is divided or bifurcated as it leaves the commutator. Both the branches are wound round the electromagnets. One of these is directly returned to the opposite pole of the commutator, without doing any work other than the excitation of the magnets. The second wire, on leaving the electromagnets, is continued to form the external or working circuit, and is ultimately reunited to the first wire. This arrangement seems to be an exception to the rule against trying to do two things at the same time, because it is admitted that the compound-wound machine is a much better working machine than the shunt. It appears that the sections of the wires can be so proportioned that a nearly uniform current flows in the working field notwithstanding variations in the quantity of work to be done. It is not necessary for the purposes of the case to explain why this should be, and if it were necessary I am not sure that I am able to explain it. It is a question of the mathematical theory of current electricity. But it is agreed that the compound-wound machine, when the wires have the proper relative conducting capacity, gives better results, as regards uniformity and steadiness of the current, than are attained by either the series or the shunt, and this explains the importance of the right to use this invention to the parties concerned. I may here observe it is not clear to me that either Varley or Brush were at first fully aware of the scientific and practical importance of the principles of compound winding. Varley was the inventor, or one of the inventors, of the "series" machine, and both Varley and Brush were doubtless aware of the advantages and disadvantages of the "series" and the "shunt." The idea of introducing the two methods into the same machine is one that would very naturally occur to anyone familiar with the subject, and practically conversant with dynamo machines. Assuming that this is intelligently done with the object of getting a better working machine through the union of the series and the shunt than is attainable by either of these modes of winding singly, then the invention is a proper subject of a patent, and it is not necessary to its validity that the patentee should have foreseen all these advantages which have been realised through the subsequent introduction or extension of electric lighting with the incandescent lamp. I may also observe that in Brush's specification, as well as in the specification, the mode of winding is only treated as one among many other parts of a dynamo machine, and it is quite possible that a reader, even if conversant with the subject, might peruse either of these documents without having his attention specially called to the novelty of the system of compound winding. But neither will this consideration affect the question. An inventor may describe his invention clearly without proclaiming it as a very important discovery, and the question is whether compound winding is clearly described in Varley's specification. The specification in question is No. 4,905 of 1876, and its title is "Improvements in Apparatus for Producing the Electric Light, parts of which Invention are Applicable to Other Purposes." The alleged anticipation is contained in the two paragraphs, page 4, lines 11 to 21—"Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce the electric light." I interrupt the reading to remark that in the words I have read the writer only announces what he is going to do, and does not profess to be explaining his method. This obvious, and, I should have thought, superfluous, criticism disposes of many pages of evidence in which witnesses are brought to say that

announced. The Lord Ordinary has held that the claim referred to is not covered by a provisional specification on the ground that although the construction of the commutator as perfected is not materially varied, yet, as the variation represents a distinct principle, and is directed to an object distinct from that which is indicated in the provisional specification, the two things cannot be regarded as identical inventions. There is much force in the Lord Ordinary's view on this question; but we consider it unnecessary to come to a decision upon it, because we are all of opinion that if there had been no more serious objection to the Brush patent than this, it would be only fair to the patentee that he should be allowed an opportunity of disclaiming this variation on one of the patented improvements. But this is not the condition of the case as it arises for decision; because we are agreed that the patent is invalidated in its essential and fundamental privilege by reason of the prior publication and use by Varley of the invention of compound winding for which this exclusive privilege is given. For these reasons I am of opinion that the interlocutor of the Lord Ordinary should be adhered to and the decree of reduction of the patent pronounced.

The **Lord President**: That is the opinion of the Court.

On the motion of **Mr. Daniell**, counsel for King, Brown, and Co., the Brush Corporation were found liable in expenses.

COMPANIES' MEETINGS.

NATIONAL TELEPHONE COMPANY, LIMITED.

The tenth annual ordinary general meeting of this Company was held on Friday last at the Cannon-street Hotel.

Mr. F. R. Leyland, who presided, said that it had been thought desirable to put into the year's accounts the whole of the expenses of the amalgamation—that was to say, the Government tax on the increased capital necessary, and the tax on the transfer from the United and the Lancashire and Cheshire Companies to the National Company. They had gone on the principle that everything that could properly be put to the expenses of the year ought to be paid out of revenue—a policy which he thought would commend itself to the shareholders. As stated in the report, the Directors, in view of the near expiration of the Company's patents, thought it prudent to strengthen the reserve account, and they proposed, under article 113 of the articles of association, to transfer to this account £40,000, leaving £11,113 to be carried forward to next year. This course he hoped would meet with the approbation of the shareholders in view of what might happen when their patent rights ceased. Referring to some statements recently made, and more especially to a speech of the Duke of Marlborough's in the House of Lords, to the effect that telephonic service was obtained much cheaper abroad than in this country, he observed that there could be no comparison as to the cost between Christiania and Stockholm and such cities as London, Manchester, Liverpool, and Glasgow. In the construction of lines in Norway and Sweden the poles were on the spot, whereas they had to be brought to this country, and distributed to the various places where they were required, at considerable cost. Again, in Norway and Sweden telephone companies were not subjected to a tax of 10 per cent. on their gross income, nor had they to pay anything for wayleaves, as was the case in this country. Having given a detailed statement of the cost of the service in the principal cities of the Continent and America, he said that the National Telephone Company had not much to learn from these places on the score of cheapness when their respective conditions were compared. The Directors had constantly recognised the importance of economy in working, and the efficiency of their service. To attain the latter object they had removed all their antiquated switchboards, and had replaced them by others of modern construction, whilst by joining one exchange on to another they had reduced very considerably the number of the exchanges, the multiplicity of which had been one of the defects of the London system. They intended as they went on to get, if possible, the whole of the work done with one or two exchanges. The extension of the Company's business during the past year had been very satisfactory. The important trunk lines connecting London with the principal towns in the Lancashire, Yorkshire, and Midland districts were completed as far as Edgware in January last, and the service proved to be perfectly clear and distinct. The Directors had every confidence that the communication between London and the North would be established by the end of this month. A large number of additional trunk lines connecting various towns in the provinces had also been commenced during the year, many of which had been completed. He was glad to say that late on the previous night they had got from the office telephonic communication with Manchester, Liverpool, and Birmingham. These trunk lines supplied a much felt public want, and would add greatly to the strength of the Company. The Directors believed it most important to continue the policy of developing and improving the Company's system, and of giving greater facilities to the public. The capital required for this purpose the Directors proposed to raise by the issue of debenture stock or preference shares as might be found best for the interests of the Company. The accrued rental for the year ending April 30, 1890, was £364,704, being an increase of £45,162 over the accrued rentals of the National United and Lancashire and Cheshire Companies. The working expenses for the same period amounted to £148,457, being 40·7 per cent. on the accrued rental, whilst the working expenses of the three companies before the amalgamation had been 47·7 per cent. The Directors had taken over the business of the Northern District Telephone Company, Limited, a month ago—a measure which he thought would be advantageous for the National Company. Owing to the fact that the Postmaster-General had not given notice to purchase the Company's business under the power reserved by the terms of his license, he could not do so for another period of seven years. He concluded by moving the adoption of the report and accounts, and the declaration of a dividend at the rate of 6 per cent. per annum on the preference and ordinary shares.

Mr. J. S. Forbes seconded the resolution, which, after a brief discussion, was carried unanimously.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY, LIMITED.

The half-yearly general meeting of this Company was held last week at the City Terminus Hotel.

Mr. S. W. Silver presided, and, in accordance with the object of the meeting, proposed the declaration of an interim dividend of 5 per cent., tax free. He stated that this distribution was justified by a rough estimate of the amount of the sales in the past six months, which had exceeded that of any previous half-year, notwithstanding the severe competition and the considerable increase in the price of the raw material. He was glad to be able to inform them that the works were fairly well employed.

Mr. Gray, the managing director, seconded the motion. He reminded them that the Company's workpeople at Silvertown were out on strike from September 18th to December 10th last, and stated that this did not cause them much loss, as they could execute their orders from their works in France. The strikers were aided by some lawless ruffians in intimidating and using violence to the Company's respectable workpeople, who had desired to continue at their duties. If the police authorities had taken proper measures the extension of the strike would have been prevented, the places of the small number who went out on strike at the beginning would have been filled up by the new men, and the strike would have ended in a week. As it was it continued for about 12 weeks, and the loss to the workpeople was about £20,000.

The motion was carried unanimously.

ELMORE'S WIRE MANUFACTURING COMPANY, LIMITED.

The first general meeting of this Company was held at the Cannon-street Hotel on Monday.

Mr. George Smith, who presided, said that, notwithstanding the adverse condition of the financial world at the time of launching the Company, about 500 applicants subscribed for the shares, and an ample allotment had been made to carry on the business of the Company. Application had been made to the committee of the Stock Exchange for a quotation and settlement, which would doubtless be granted. Twelve acres of freehold land adjacent to the present Company's works at Haigh-park, Leeds, had been secured, and manufacturing buildings were being erected thereon under the supervision of their managers. Orders had been given for plant, and these would be followed up judiciously by others until the factories were completed. The policy of the Directors had been to work with, rather than against, the wire manufacturing trade, and he was happy to say that a very substantial number of Birmingham wire-drawers had offered to take the whole of their output of spirals for 1891, with prospective arrangements for continuing the agreement, and that at a price which would yield satisfactory results. The terms for carrying out the offer referred to had been approved, and the agreements would shortly be executed and exchanged by the parties concerned. The Directors, therefore, felt that they might congratulate the shareholders upon their prospects.

At an extraordinary general meeting held subsequently a resolution was passed altering the articles of association to comply with the requirements of the Stock Exchange Committee with a view to obtaining a special settlement and official quotation of the shares of the Company.

COMPANIES' REPORTS.

CROMPTON AND CO., LIMITED.

Directors: Sir Charles Grant, K.C.S.I., Bernard Gibson, Esq., Carleton Fowell Tufnell, Esq., Rookes Evelyn Bell Crompton Esq., and John Francis Albright, Esq. (managing directors).

Second report of the Directors, to be presented at the annual general meeting of the shareholders at the City Terminus Hotel, Cannon-street, in the City of London, on Monday, the 21st inst., at 2.30 p.m.

The net profits for the year amount to £10,610. 1s. 7d., and after payment of the interim dividend last December, and providing for debenture interest and other payments set out in the accounts, there remains a balance of £6,030. 6s., from which the Directors propose, after setting aside a sum of £500 as a provision for doubtful debts and contingencies, to declare the usual dividend of 7 per cent. per annum upon the preference shares, and 5 per cent. per annum upon the ordinary shares, carrying the balance forward. The business of the Company has greatly increased, necessitating considerable extension of the works and large additions to plant. The contract for the public lighting of Chelmsford has been carried out, and the result has given great satisfaction in the town. It

NOTES.

Exhibition at Lyons.—A grand national and colonial exhibition is to take place at Lyons in 1892.

Stockholm.—Tenders are invited for the electric lighting of Stockholm, to be sent to the director of gas works by September 1st.

Bremerhaven.—The Municipality of Bremerhaven have decided to put off the electric lighting of the town till the 1st January, 1891.

Australian Cables.—The Eastern Extension Telegraph Company notify that telegraphic communication with Australia, New Zealand, and Tasmania is now restored.

Huddersfield.—The provisional order granted to the Corporation of Huddersfield has been before the examiner and found to comply with the Standing Orders of Parliament.

Long Distance Telephones.—The National Telephone Company reports that communications have been established between London and Liverpool, Manchester, and Birmingham.

Frankfort Exhibition.—The application forms for space in the Frankfort Exhibition next year have been issued, and copies can be obtained from the secretary, Herr Carl Stiebel, Frankfort-on-Maine.

Japan.—In Japan there are now five electric lighting companies, supplying 11,000 lamps, with a total capacity for 33,000 lamps. The Royal Palace and the Government journal office are now lighted.

Portuguese Cables.—Orders appear in the Portuguese official journal authorising the Government to proceed at the cost of the State to lay and work a cable giving communication between Lisbon and St. Michael, Terceira, and Fayal in the Azores.

Electric Welding.—The American Wheel Company, Chicago, which has bought up all the principal wheel companies of the United States, has heretofore sold its wheels without tires, but will now tire all wheels, using the Thomson electric welding process, for which it will pay royalty on at least a million welds a year.

Electrical Enterprises in Saxony.—A telegram, through Reuter's Agency, from Dresden states that a concession has been granted to a civil engineer and a firm of bankers in that city authorising them to establish a network of cables for purposes of transmission of power and electric lighting direct from some coal mines through 168 industrial towns in Saxony to Dresden.

Gas at Paris.—There is some talk of lowering the price of gas in Paris. It would not be difficult to do this as the price is somewhere about double that of London, but the move is regarded with some disfavour by electric light companies, as it is thought it would be impossible in this case to keep the price for electricity up to the present charge of 1½d. per 100 watt-hours.

Railway Instruments.—The contract for the supply of electrical instruments on the London and North-Western Railway for the ensuing year has been again obtained by Woodhouse and Rawson United. This contract has now been held by them for several years, and they have also been awarded the contract for the supply of instruments to the Caledonian Railway for the year.

Electric Light in London.—The Unopposed Bill Committee of the House of Commons decided last Friday to confirm the orders granted by the Board of Trade for the electric lighting of the district adjacent to the Crystal Palace by the Electric Installation and Maintenance Company, and for the lighting of the whole of the parish of Paddington by the Metropolitan Electric Supply Company.

Montlucon.—The gas company at Montluçon has been to law with reference to the right of the electric light company to use the streets. The gas company has apparently won its case, but in so doing will suffer. The electric light was not progressing, but the action of the gas company caused public feeling in support of the electric light, and now the concession for gas which expires in 1895 will not be renewed, and, on the contrary, it will be required then to take up its pipes and relay the streets.

"Gas and Electric Directory."—We have to acknowledge the receipt of the "Gas, Water, and Electric Lighting Companies' Directory" for 1890, edited by Chas. W. Hastings (Hazell, Watson, and Viney)—a compendious and useful compilation. We notice that a new feature has been added in the shape of a list of electric lighting undertakings, giving the names of some 50 electric light companies, with details of date of formation, capital, system, capacity, price per unit, names of secretary and electrician in charge, area of supply, and other information.

Wimbledon.—At the meeting of the Wimbledon Local Board the enquiry of the Local Government Board into the proposed loan of £30,000 was discussed. It was moved that the enquiry should be deferred till after September, and after an amendment to defer it altogether was lost by the casting vote, the motion was carried, but with the addition of "1891" after the word "September." The matter is therefore deferred for the present, and will be made a test question in local politics, some members maintaining the expenses to be more nearly £50,000 or even £100,000.

Mining Exhibition.—The international mining exhibition now being organised and rapidly perfected at the Crystal Palace was intended to be opened, as we have mentioned, on the 15th of this month, but owing to some of the colonial exhibits not being ready the opening is now arranged for next Monday, the 28th July. The scheme has grown, as exhibition schemes have a habit of doing, into one of much more extensive scope than at first intended, and it bids fair to prove an important show, both from mining, from colonial, and from engineering standpoints generally.

Ferranti Mains in Trafalgar Square.—The roadway leading past the lions in Trafalgar-square is up as we write, and the workmen are busy laying the Ferranti trunk mains jointed in the manner we recently described. Four of these 10,000-volt mains are laid side by side in two wooden troughings, separated from touching by wooden slips and filled around with melted bitumen. The mains, ready jointed in lengths, seem easy to handle and have a certain flexibility that allows of easy laying. They are doubtless intended to take the main current from Charing Cross on to the Grosvenor.

Public Lighting of Christchurch.—At the meeting of the Christchurch Town Council the clerk stated that no reply had yet been received from the Christchurch Gas Company as to the contract for lighting the town for the ensuing season, although letters had been written to them

on the subject. Mr. Tucker said he did not think the gas company were treating the Council in a proper manner. On the motion of Mr. Druitt, it was resolved that the clerk to the gas company be written to and informed that unless an answer was received by a certain date the Council would proceed to consider other means of lighting the town.

Paris Meter Prizes.—The Paris Municipal Council offers £650 in prizes for electric meters; £500 for a satisfactory meter adapted both for direct and alternating currents, or £250 for a satisfactory meter adapted only to one of these; £80 is given as a prize for meters adapted for both, and £40 for one only in case an important degree of progress has been made without attaining the power of giving every satisfaction. Conditions can be had at the Hotel de Ville (Bureau de la Voie Publique et des Promenades). Specimens, accompanied by sealed envelopes, with description and names, to be at the Municipal Electric Works at the Halles Centrales, between August 25 and 31.

Paris Underground Railway.—The Paris Metropolitan Railway scheme of M. Bunau Varilla, which M. Eiffel proposes to carry out, is now before the Paris Municipal Council. Nearly five miles of the railroad will be underground, more than half a mile on the surface, and almost a mile and a half will be elevated on an iron arcade. The continuous brake and block system is adopted in the plan, and the electric lighting of the tunnels will be done by machines worked by the motors used for ventilation. Only two classes of carriages are to be employed. The company will bind itself not to raise fares on Sundays and holidays, and to have workmen's trains morning and evening, for which through return tickets costing only twopence will be issued.

Westinghouse Electric Cars.—The first electric tramcar motor of the manufacture of the Westinghouse Electric Company has now been in operation on the Pleasant Valley Electric Railway line, in Allegheny City, U.S., for some time, and the success of the machine is reported as being established beyond question, and a number of electricians and tramway men who have examined the motor praise it highly. The Westinghouse Electric Company are stated to have already secured orders for the equipment of 17 street railways, aggregating a business of 300,000dols., although the company has only been in the field for the last two or three months. The mechanism shows great mechanical strength and good workmanship, and enquiries and orders are being very widely received from all parts of the States.

Fulham.—At the London County Council the Highways Committee had considered a letter from the Board of Trade forwarding for the observation of the Council a copy of an application from Messrs. Woodhouse and Rawson United, Limited, for permission to purchase from the West Middlesex Electric Lighting Company the undertaking authorised by the Fulham District Electric Lighting Order, 1884, which order was revoked by the Board in October last. The committee recommended that the Board of Trade be informed that in the opinion of the Council the permission asked for by Messrs. Woodhouse and Rawson United, Limited, should not be granted unless the provisions of the Fulham District Electric Lighting Order, 1884, be so modified as to make them accord with the orders recently granted by the Board. This was agreed to.

Raw Hide Gearing.—Gearing made out of raw hide is much in vogue in American practice for electric traction cars. The hide is sometimes compressed by hydraulic pressure, and is turned up with a hard polished though flexible facing, which is silent and easy in working. The disadvantage that has been found in practice is that the wear is unequal. To remedy this, a recent method adopted is to make the teeth slanting and to arrange the number of teeth so that they are not in direct ratio but prime to each other, as eight to 33, not 32. In this way a different tooth gears at each revolution and a different part of the tooth wears, thus equalising the wear. We are not aware that raw hide gearing has been practically tested in this country, but now that electric car traction is tending to take an important place in electrical engineering, it may be worth while for our engineers to investigate this method of gearing.

Deptford Trunk Mains.—The Highways Committee of the London County Council have reported that they had considered a notice from the London Electric Supply Corporation (with one plan), of intention to lay trunk mains in Stamford-street, York-road, Sutton-street, and Belvedere-road, together with a letter from the company, asking that, as it had arranged a new route for its mains, this notice might be taken in substitution for that dated April 18th, 1890, the works referred to in which were approved by the Council on May 1st last. The committee therefore recommended that the sanction of the Council be given to the works referred to in the notice (Registered No. 96) of the London Electric Supply Corporation, dated June 19th, 1890, upon the following conditions: That the distributing mains be laid at the same time as the trunk mains, in order to avoid a second interference with the same streets. This was agreed to.

Saunderson Hydro-Carbon Arc Lamp.—This lamp, which we recently described, and which it will be remembered claimed to give practically double the light for the same consumption of energy by the introduction of hydro-carbon vapour in the arc through an asbestos wick in the lower carbon, has now been publicly tried for the last five weeks at one of the large railway stations in London, and minute and careful tests have been constantly taken upon the light. The results are stated undoubtedly to more than confirm Dr. Hopkinson's photometric tests (whose report we gave May 16, p. 386), and it is hoped shortly that the tests in actual working can be made public. The great increase in actual light to be obtained from the same engine power by the simple change of one of the carbons cannot but be expected to greatly interest and influence companies employing the arc lamp for public lighting.

Western Union Offices Burnt.—An explosion at the Western Union Telegraph Company's offices occurred at seven o'clock in the morning, last Friday, in the battery-room on the sixth floor, and the flames, which immediately broke out, soon spread to the portion of the building above, including the operating-room and the offices of the Associated Press, both of which were gutted, while the lower floors were drenched with water. The loss is estimated at 250,000dols. The wires of the Western Union Company were concentrated in the building, and the result of the fire was that the service was greatly crippled. Business on the exchanges in New York and elsewhere was delayed, owing to the absence of despatches. Only about 40 operators were on duty at the time, and all succeeded in effecting their escape. The burning of the wires prevents the receipt of despatches from Sandyhook and Fire Island reporting the arrival of vessels.

Transmission of Power.—At the recent meeting of the Société Internationale des Electriciens, M. Hillairet described the interesting transmission of power by electricity which has been carried out near the town of Doméne, in Isère, France. In this installation power equal to 200 h.p delivered is transmitted to a paper mill at a distance of 3¼ miles from the waterfall utilised. Lantern slides from photographs taken last winter were shown giving different views of this installation from the waterfall and works passing along to the motor, with all the accessories necessary for the transmission. An interesting feature of the installation is that during the winter the little generating works is entirely cut off by the snows for two months from the paper mill where the force is utilised, but nevertheless continues to work regularly. The telephone enables it to be known whether all is going well, and keeps up communication with the inhabitants of the valley.

Chiswick.—At the fortnightly meeting of the Chiswick Local Board, Mr. Waters moved "That in the ensuing session of Parliament application be made for a provisional order authorising the Chiswick Local Board to manufacture and supply electric light in the parish of Chiswick." He stated that his immediate reason for proposing this was owing to the notice received from the gas company as to the increase in the price of gas—in his opinion, the increase was quite uncalled for. If the Board merely approved of the motion he should be content, as they could then discuss ways and means in committee. They had had two notices from companies announcing the intention to apply to Parliament for powers, and he would like the Board to be first in the field. Surely, if it would pay foreign companies to come there and establish an expensive plant, it would pay the Board. From estimates supplied to him, it appeared that under a large scheme a profit of £4,000 would be effected, and under a small one something like £1,250. The motion was carried.

Electric Lighting Projects.—Several new projects for electric lighting in London have come before the London County Council, and in all the Highways Committee have reported that the following notices of intended applications next session for provisional orders under the Electric Lighting Acts had been received: St. James and Pall-mall Electric Lighting Company, for the parishes of St. James, Westminster, and St. George, Hanover-square; Brush Electrical Engineering Company, for the parishes of Fulham, Hammersmith, Islington, Shoreditch, St. Luke, Clerkenwell, Bethnal Green, and districts of Hackney and St. Saviour; Laing, Wharton, and Down Syndicate for the City of London (east and west districts), parishes of Shoreditch and Islington, and districts of Hackney and Whitechapel; Westminster Electric Supply Corporation, for the parishes of Paddington, Chelsea, St. Marylebone, Kensington, and St. Margaret and St. John, Westminster (part of); New Cadogan and Belgrave Electric Supply Company, for the parish of St. George, Hanover-square, and parish of Chelsea; London Electric Supply Corporation, and Metropolitan Electric Supply Company, whose areas were not specified.

The Gas (and Electric) World.—Our well-known contemporary and presider over the interests of gas engineers, the *Gas World*, has an important announcement to make this week. It has acquired the copyright and goodwill of the *Gas and Water Review and Journal of Electric Lighting*, and in future this will cease to be published, being incorporated with the former. The *Review and Journal* had given in its strong adherence to the belief in electric lighting, and has been vigorously advocating the introduction of electric light by gas companies. The consolidated paper announces that the incorporation will not affect the policy hitherto advocated by the *Gas World*, which, as far as we can learn, seems a waiting game, "a watchful eye" rather than any great belief in the future of the new illuminant. "As in the past," says the editorial announcement, "we will continue to devote the greater part of our available space to matters relating to the manufacture and distribution of gas; but we mean at the same time to keep a watchful eye on the progress of the electric light, and to supply reliable accounts of its development, so that our readers may be kept advised of what their electric enemy or friend —which ever way they feel inclined to regard it—is doing. We do this on the principle that forewarned is forearmed." This is not conversion—it can hardly be expected—but it argues a nice and critical calculation and application at last on the part of gas engineers, and possibly foreshadows more energetic tactics.

Leamington.—At the meeting of the Leamington Town Council last week, the town clerk stated that he had had notices served upon him by three companies who proposed to apply to Parliament for provisional orders for the electric lighting of Leamington. These companies were the Municipal Electric Lighting and Power Company (London), the Electric Installation and Maintenance Company (London), and the Midland Electric Lighting and Power Company (Messrs. Hookham and Chamberlain). The Mayor remarked that they had instructed their town clerk to apply on their own behalf to Parliament for a provisional order, and no other company would have a chance of obtaining an order when it was understood that the Corporation themselves intended to get one. Alderman Wackrill said it was understood that the town clerk should make the application as soon as possible. The town clerk observed that the Midland Electric Lighting Company's solicitors said in their notice, "and also to confirm the present arrangements for lighting the borough." The Mayor could not see what confirmation of the present arrangement there could be. The Board of Trade could not recognise the company's present position. The town clerk thought that the company's object was to strengthen their case by showing that they had been on the ground for the last two or three years. The Mayor considered that this was probably so. The matter was left in the hands of the town clerk.

One Station and Two Local Boards.—A difficult point has come before the Moss Side (Manchester) Local Board. A communication was read from the Board of Trade, under date July 19, stating that the suggested amendments of the Moss Side Board in the provisional order applied for by the House-to-House Electric Supply Company for lighting the district of Stretford and Moss Side by electricity had been carefully considered, and that the Board of Trade could see very great difficulties in the way of keeping separate accounts for the portions of the undertaking situate in the districts of the two local authorities, and therefore regretted that they could not accept the Local Board's amendments. The clerk said that Stretford had been joined to Moss Side in the provisional order without consulting the two authorities. When Moss Side consented to the granting of the order they understood it was for Moss Side only. Now it was intended to build one station with machinery for producing electricity for the two districts, and when the time came for purchasing the

business (the Moss Side Board having the option of purchasing the undertaking at the end of 20 years), the fact of having only one station would raise a serious difficulty. Only one district could purchase it, and it would be too large for one district alone. After some discussion a subcommittee was appointed to confer with the Stretford Local Board as to whether, under the circumstances, the confirmation of the provisional order by Parliament should be opposed.

Electric Lighting in Theatres.—In an interesting paper before the Association Internationale des Electriciens, M. de Nerville gives the results of a series of measurements upon the lighting power he has made at various theatres in Paris. The first were taken in the Opera House; in the auditorium the mean intensity is 10 candle-metres. The other measurements gave

Orchestra stalls	10	candle-metres.	Horizontal surface.
Pit	13	"	"
1st circle (centre) boxes	8	"	Vertical surface.
2nd " "	10	"	"
3rd " "	15	"	"

The light varied in the crushroom between 10 to 20 candles, on the balcony between seven and 14 candles, in the passages one to five candles, it is nearly constant at 15 on the staircase, and about five candles at the buffet. In the Hippodrome the light is much more intense. At the ends of the larger axis of the building M. Nerville found 44 candle-metres on a horizontal surface, 15 to 33 on a vertical surface turning on its axis. At the extremities of the small axis 16 to 20 candle-metres on the horizontal surface, and 50 on the vertical surface. In the track it was 72 candle-metres horizontal, 22 to 75 on a vertical surface. There are means of increasing the light by supplementary lights. For instance, the scene of the woodman in "Joan of Arc" is lighted by a special arc lamp of 50 amperes, which makes the lighting intensity 130 candle-metres. These data may prove useful in future installations of electric light in theatres.

Missed at the Edinburgh Exhibition.—Although the Electrical Exhibition at Edinburgh is singularly attractive and full, there are yet several exhibits which we should have expected and desired to see there to render it a complete exposition of the latest and most interesting developments. One of the most noticeable is the absence, or rather the non-working of the electric tramway. This is certainly a serious omission. The tramway is there, and was to have been working in May, and now in July only experimental trials have been made. There have been, we believe, some unfortunate difficulties on both sides between the exhibition authorities and contractors, but by this time we sincerely trust these have been arranged, and we hope the railway is at work. The other omissions of exhibits we would like to have seen are the electric welding, the turbo-generator and dynamo, and an alternate-current motor in working order. We believe we are right in saying that the Electric Welding Company, now that the stress of company formation is practically over, are thinking of sending in a machine which could not fail greatly to interest shipbuilders on the Clyde, and is, in fact, an exhibit every visitor expects to see. The Parsons 16,000 revolution steam-engine and dynamo is a most interesting exhibit, and can never fail to interest visitors, and at present the only place the ordinary engineering world expect to be able to see them is at an exhibition—and it cannot see them here at present. A real working alternate-current alternator, by Ganz and Co., Tesla, possibly Swinburne, or others, would have been justly regarded as a most interesting and novel exhibit, and efforts to show the very latest in this direction ought to have been made. Some months remain: perhaps it is even yet not too late to remedy these omissions, and the manufacturers, when they know how much their inventions are missed, will doubtless hasten to do all they can to complete this very fine exhibition at Edinburgh.

Barnsley.—A very animated and prolonged discussion upon the electric lighting question took place at the monthly meeting of the Barnsley Town Council last week. Alderman Blackburn introduced the question, and, in reviewing the position, said that when the agitation was on foot with respect to the advance in the price of gas, a public meeting was held at which a resolution was passed asserting the advisability of bringing the electric light into the town. It was agreed by that Council that the resolution of that public meeting should be respectfully received, and that the Council should give to the subject its earnest consideration. On the 9th of November it was decided to apply for a provisional order from the Board of Trade to enable the Corporation to maintain electric works and supply electricity within the borough, and that provisional order, in its amended form, had been agreed to by the Board of Trade, passed by the House of Commons, and was now awaiting the sanction of the House of Lords. In addition to the Council applying for the provisional order, the Park and Lighting Committee had visited various towns in the country for the purpose of finding out all they could in connection with the question, and then, having made the fullest enquiries, they had made application to several electric companies asking on what conditions they would set down an installation, and what they would charge the Corporation for it if they bought it from them after a certain time. They found, however, that the expenses were so outrageous that it was impossible to entertain the terms. The committee then asked for tenders for the putting down of a plant for the Corporation; called in the assistance of Mr. Bromley Holmes, of Liverpool, an eminent electrical engineer, and finally came to the conclusion to recommend to the Council the accepting of the Westinghouse Company's tender. He would be frank with the Council. There was not that unanimity of feeling in the committee in connection with the passing of the resolution that he had expected. The committee, however, had pressed on as fast as possible. The provisional order they had practically obtained held good for two years. The sooner they introduced the light the better, as the Co-operative Society had now introduced it for themselves, and other consumers might do so if they delayed. In the discussion which ensued, the principal point seemed to be that Ald. Marsden described a statement of Mr. Wray, that he (Ald. Marsden) had said he would spend £10,000 rather than see the electric light, as a deliberate lie. It was afterwards explained that the Alderman had suggested trying to buy the gas company at a reasonable price, and if not successful he would go in with the electric light. The town clerk, who was Mr. Wray's authority for the above statement, said the actual statement by Mr. Marsden was that before he would sit down with the "proposed area," he would spend £10,000 in opposing the provisional order; and that, said Ald. Marsden, was a very different thing. This, maintained Mr. Wray, came to the same thing, and was an extraordinary thing for any man of business to say. The debate was eventually adjourned for a fortnight.

THE EDINBURGH EXHIBITION.—XII.

At stand No. 59 Machinery Hall, Messrs. Paterson and Cooper exhibit a good assortment of dynamo machines, arc lamps, measuring instruments, and general electric light fittings. This firm's standard pattern of single magnet Phœnix dynamos is well-known, and is shown in Fig. 1.

FIG. 1.

Different sizes are exhibited, suitable for belt or rope driving, and in addition is shown a Phœnix dynamo coupled direct to a "Westinghouse Special" engine, particularly suited for ship lighting or for employment where the saving of space is an object. This combination is shown in Fig. 2, the cast-iron bedplate which supports the engine taking the place of the machine bed in Fig. 1, and forming, as does the latter, the yoke to the magnet. At a speed of 600 revolutions per minute the dynamo gives 45 amperes and 100 volts, furnishing power sufficient for 75 lamps of 16 c.p. each. The engine works at a steam pressure of 100lb. to 120lb. per square inch, the speed being automatically governed. The cylinders are 4½in. in diameter, and the stroke 4in.

Amongst their electric lighting accessories are to be seen polished slate distribution-tablets for ship work, fitted with ammeter and voltmeter fuses, and spring switches, labelled with the names of the various circuits; also a large number of fittings specially designed for ship work. For saloons and cabins the lamp brackets and pendants are silver-plated, and of artistic design, while for deck and cargo work fittings of a very strong design are employed, suited to the rough work for which they are intended. A portable cargo lantern has a cluster of three 16-c.p. lamps, and is provided with a strong outer guard for protection; the hold lamp fitting is made of heavy iron, and has hinged to it a strong shutter, so that when closed up cargo can be placed in the hold against it without fear of the fitting or lamp being damaged. In ordinary cases these lamps are only used in port when loading or discharging cargo, but should the hold be used for cattle or sheep they are very serviceable at sea. The regulation types of mast and side lamps fitted electrically are shown, each having two 16-c.p. lamps. It is claimed that the light is visible at a greater distance and clearer than that from oil lamps, also that in stormy weather they will burn perfectly steady when it would be difficult to keep oil lamps burning. Another appliance used in connection with ship work, and shown at this stand, is a small motor fan or saloon punkah. These have been applied to several of the Eastern-going ships, fitted by Messrs. Paterson and Cooper, and the cool atmosphere provided by their use has added much to the comfort of the passengers. The fan attached to a small electromotor is placed near the end of the saloon, and furnishes a continuous supply of cool air, a switch for turning the driving current on or off being conveniently situated under the control of the steward.

Models of several of the steamers which Messrs. Paterson and Cooper have fitted with electric light are shown. Amongst these is the ss. "Parisian," a handsome vessel, 440ft. in length, built for the Allan Line Mail Service by Napier and Sons, of Glasgow, in 1881. Her carrying capacity is 9,663 tons, and her engines are of 6,000 h.p. She is fitted with 500 lamps, the current being supplied by two Phœnix dynamos, each belt driven from a separate high-speed vertical engine. Another model shown is that

FIG. 2.

of the ss. "Perth," the fourth vessel fitted by Messrs. Paterson and Cooper for the Dundee, Perth, and London Shipping Company. This vessel has just been completed by the builders, Messrs. W. B. Thompson and Co., of Dundee, and, in addition to the ordinary lights for the cabins and passenger service, is fitted with special fixed lights for cargo work in the holds and on decks. In addition to the models, several photographs of the steamers fitted by the firm are also on view.

The Phœnix arc lamp, manufactured by the firm, has a place at the stand, and is shown with its protecting cover removed in Fig. 3. The lamp is of the differentially wound class, and is equally well adapted for burning in series on a constant-current circuit or in parallel on a constant-potential circuit. In the drawing, A represents an electromagnet wound with coarse and fine wire coils,

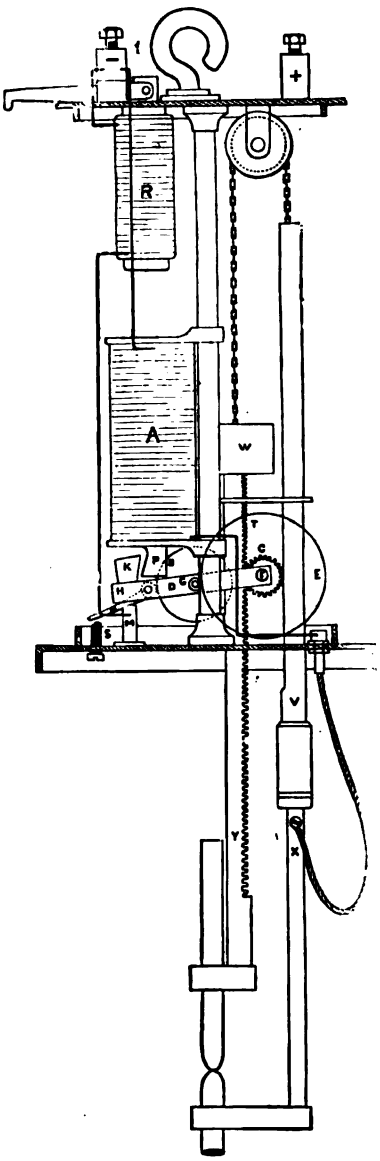

Fig. 3.

the pole-pieces, P, acting upon an armature, K, fastened upon a frame, H D, pivoted at F. The frame carries a brake-wheel, B, on the axle of which is fastened a small pinion, G, and a brake lever, N, made to grip B by a helical spring attached to the frame. The pinion, G, gears into the larger toothed wheel, E, on the axis of which is a pinion, C, engaging with the rack, Y, of the positive carbon rod. This rod carries a weight, W, which in descending enables the negative rod, V X, to be lifted. When no current is flowing, the brake lever, N, rests on the screw, S, which releases the brake-wheel and allows the carbons to come into contact.

The action of the lamp is as follows: The current enters the right-hand positive terminal, passes through the framework of the lamp to the rod, Y, and thence to the positive carbon. It returns by the insulated rod, X, and flexible cord attached to it, passing through the coarse wire coils on A, and then to the negative terminal. The magnet attracts K, raising the frame, H D, this causing the lever, N, to grip the brake-wheel, and the toothed wheels, E and C, turning round the rod Y is lifted, and X lowered, the arc being thus formed. As the carbons consume, the difference of potentials at the lamp terminals rises. The current in the fine wire coils round A, which are a shunt to the terminals, consequently increases. This weakens the electromagnet, A, and allows the frame, H D, to fall gradually, and the carbons to approach each other. When the lever, N, comes in contact with the screw, S, the brake is released, allowing the carbons to approach as the consumption continues. While the lamp is burning the end of the lever remains quite close to the screw. If the carbons burn out, or from any other cause the circuit through them is broken, the frame, H D, drops on the insulated pillar, M; this completes the circuit from the lamp frame through the German silver resistance, R, to the negative terminal, thus preventing a break in the continuity of the circuit when the lamps are in series.

When burning in parallel on a 65-volt circuit, the bypass resistance, R, is removed. In this case the usual auxiliary resistance, absorbing about 15 volts, is placed in the circuit of each lamp. The pole-pieces, P, and armature, K, are shaped so that for the same current and difference of potentials the pull on the frame is in every position similar; but should the current or difference of potentials alter, a small movement of the frame at once adjusts the arc to its normal strength. A dash-pot attached to the armature checks any sudden movement due to impurities in the carbons, etc. These lamps are installed at Peter Robinson's Oxford-street and Regent-street houses, at the Albert Institute, Dundee, and in many other important installations.

A variety of electrical measuring instruments, for which the firm has justly a reputation, is, of course, exhibited. Among these are the well-known permanent magnet Ayrton and Perry instruments, which the firm has manufactured since their first appearance, and which still find a good sale. Several Phœnix dead-beat electromagnet ammeters and voltmeters are also shown, the controlling force in these being furnished by a strong spring instead of by the weak directional effort of an electromagnet with a small core. These instruments are made to measure currents up to 2,500 amperes. Cardew voltmeters of the latest pattern, as well as all forms of instruments used for electric light testing, are to be seen.

A model of a new system of railway carriage construction, designed by Mr. R. M. Short, is shown, the carriage containing first, second, and third-class compartments, with lavatories, etc., electrically lighted. Though not in connection with electricity, Messrs. Paterson and Cooper have a model on view of Captain Anderson's patent hold-handy ladder, which is designed to supersede the dangerous hold ladder in use. It affords easy access to the holds, and is of great convenience to shipowners and surveyors when inspecting cargo, etc. The ladder is fitted on the ss. "City of Vienna," and other steamers of the City Line.

THE WORKING EFFICIENCY OF SECONDARY CELLS.*

BY W. E. AYRTON; C. G. LAMB, E. W. SMITH, AND M. W. WOODS, ASSOCIATES.

(Continued from page 51.)

VII.—Effect of Rest.

We next tried the effect produced on the capacity and efficiency of accumulators by prolonged rests. The five cells used in the experiments stood on porcelain insulators containing resin-oil; and as the insulators, which were specially made for the Central Institution, were taller than those commonly employed to support accumulators, and as all connecting wires were removed from the cells while they were allowed to rest, it is certain that any change in the

* Paper read before the meeting of the Institution of Electrical Engineers at Edinburgh, July 16, 1890.

cells must have been caused by internal action, and could not have been due to external leakage.

The cells, having been fully charged on June 22nd, 1889, were allowed to rest, insulated as above described, until July 2nd, that is, for 10 days. The first few curves of discharge and charge after the rest showed a considerable diminution in the capacity and efficiency; but after one week's continuous charging day and night a steady cycle was reached, the following being the times of successive discharges and charges, the limiting P.D.'s as before, being 1·8 and 3·4 volts:

TIMES OF SUCCESSIVE

Discharges.	Charges.
10h. 1m.	11h. 35m.
9h. 59m.	11h. 30m.
9h. 58m.	11h. 32m.
9h. 57m.	11h. 33m.

Curves 10 and 11 show the variation of the P.D. per cell, and on integrating these curves we obtain

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
100	198	103·8	228·2	96·4	85·8

Rest, then, of an accumulator, although left well insulated and fully charged at the commencement, alters the accumulator so that for the first few charges and discharges after the rest it is a much less valuable instrument than before. A week's continuous charging and discharging day and night, however, removes this effect to a great extent; the efficiency, however, still remains somewhat lower than before the rest.

Next, the cells were allowed to rest charged for 12 days, until August 1st. The first discharge at the end of the rest gave a quantity efficiency of only 80 per cent., so that 20 per cent. of the charge was lost. After a week's continued charging and discharging between the former limits of volts, the cells regained a steady state, but the time of charge and of discharge is now less than before this second rest. The times after the week's charging and discharging were:

TIMES OF SUCCESSIVE

Discharges.	Charges.
9h. 3m.	10h. 41m.
9h. 2m.	10h. 44m.
9h. 10m.	10h. 51m.

Curves 11 and 12 show the P.D. curves when the cells had acquired a steady state, and on integrating them we find—

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
91	176·1	96·8	213·2	94·1	82·8

We see, then, that a week's continuous charging and discharging of these cells is unable to compensate for the harm produced by their being left for 12 days fully charged. The two rests of 10 days and 12 days respectively, although followed in each case by a week's continuous charging and discharging, have reduced the discharge ampere-hours by 10 per cent., the discharge watt-hours by 12 per cent., the quantity efficiency by 3 per cent., and the energy efficiency by 5 per cent.

Third Rest.—The cells having been fully charged, a third rest of 16 days took place. On the first discharge, at the normal rate of 10 amperes, the ampere-hours were only 75. After, however, the charging and discharging at the normal rates had been continued for three days and nights, the times of discharging and charging became steady.

TIMES OF SUCCESSIVE

Discharges.	Charges.
8h. 12m.	9h. 28m.
8h. 17m.	9h. 35m.
8h. 19m.	9h. 35m.

and curves 14 and 15 show the working values of the P.D. in discharging and charging. Integrating the curves, we obtain:

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
82·6	161·3	86·2	190·5	95·8	84·7

Fourth Rest.—The cells, having been fully charged, were allowed to rest for 16 days. Curve 16 gives the values of P.D. obtained at the first discharge, and curve 17 the values of the P.D. obtained immediately afterwards in charging. Integrating the former curve, and comparing its area with the area of the charge curve, 15, obtained just before the rest, we find

First discharge after rest.		Last charge before rest.		Percentage efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
56·5	110·5	86·2	190·5	65·5	58

If, however, we compare the result of the first discharge after the rest with the first subsequent charge, shown in curve 17, we find

First discharge after rest.		First charge after rest.		Percentage efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
56·5	110·5	71·1	158·3	79·6	69·6

The cells were now continuously, without intermission, charged with the normal current of nine amperes, and discharged with 10; the discharge, as before, being automatically stopped when the P.D. per cell had fallen to 1·8 volts, and the charge when it had risen to 2·4 volts. The following give the successive times in hours and minutes in which the cycles were completed:

First discharge after rest,			5h. 40m.	First charge,		7h. 54m.
Second	,,	,,	7h. 6m.	Second	,,	8h. 30m.
Third	,,	,,	7h. 31m.	Third	,,	8h. 51m.
Fourth	,,	,,	7h. 29m.	Fourth	,,	8h. 52m.
Fifth	,,	,,	7h. 43m.	Fifth	,,	9h. 17m.
Sixth	,,	,,	8h. 0m.	Sixth	,,	9h. 24m.
Seventh	,,	,,	8h. 5m.	Seventh	,,	9h. 17m.
Eighth	,,	,,	7h. 57m.	Eighth	,,	9h. 20m.

From the last three discharges and charges we see that the cells have arrived at a steady state, and curves 18 and 19 show the steady or working values of the P.D. for these three discharges and charges. Integrating the areas of these two sets of curves, we find—

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
80	156·9	83·8	184·6	95·5	85

Fifth Rest.—The cells were now left charged for a further period of 16 days. Curve 20 gives the values of the P.D. obtained at the first discharge after the rest, and curve 21 the values of the P.D. obtained immediately afterwards in charging. Integrating the areas of these curves, we have—

First discharge after rest.		Last charge before rest.		Percentage efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
53·3	104·1	83·8	184·6	63·6	56·4
		First charge after rest.			
		58·5	128·3	91·1	81·1

Continuous charging and discharging with the normal currents between the normal limits of P.D. per cell, gave the following times for completing the cycles:

First discharge after rest,			5h. 20m.	First charge,		6h. 30m.
Second	,,	,,	6h. 18m.	Second	,,	7h. 29m.
Third	,,	,,	6h. 42m.	Third	,,	7h. 59m.
Fourth	,,	,,	6h. 54m.	Fourth	,,	8h. 19m.
Fifth	,,	,,	7h. 15m.	Fifth	,,	8h. 20m.
Sixth	,,	,,	7h. 16m.	Sixth	,,	8h. 30m.
Seventh	,,	,,	7h. 23m.	Seventh	,,	8h. 41m.
Eighth	,,	,,	7h. 34m.	Eighth	,,	8h. 44m.
Ninth	,,	,,	7h. 40m.	Ninth	,,	8h. 47m.

It was concluded from the times of the last three charges and discharges that the cells had acquired a steady state, and curves 22 and 23 show the time fall and the time rise of P.D. Integrating the areas of these curves, we have

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
76	149·5	78·3	173·2	97·1	86·3

The following table gives a *resumé* of these results, all the discharges being made with 10 amperes until the P.D. fell to 1·8 volts per cell, and all the charges being made with nine amperes until the P.D. per cell rose to 2·4 volts. Before each rest the cells were charged until the P.D. per cell was 2·4 volts.

TABLE B.

Discharge.				Charge.				Percentage efficiency.	
Duration of discharge.	Ampere-hours.	Watt-hours per cell.	Number of curve.	Duration of charge.	Ampere-hours.	Watt-hours per cell.	Number of curve.	Quantity.	Energy.
Cells in normal state.									
h. m.				h. m.					
10 12	101·9	201·7	8	11 38	104·5	230·7	9	97·2	87·4
Rest of 10 days. Cells then charged and discharged many times until brought to a steady working state.									
10 0	100	196	10	11 31	103·8	228·2	11	96·4	85·8
Rest of 12 days. Cells then charged and discharged many times until brought to a steady working state.									
9 8	91	176·7	12	10 45	96·8	213·2	13	94·1	82·8
Rest of 16 days. Cells then charged and discharged several times until brought to a steady working state.									
8 24	82·6	161·3	14	9 36	86·2	190·5	15	95·8	84·7
Rest of 16 days. *First* discharge and charge after rest.									
5 41	56·6	110·5	16	7 54	71·1	158·3	17	Ratio of first discharge *after* rest to last charge *before* rest 65·4	58·0
								Ratio of first discharge *after* rest to first charge *after* rest 79·6	69·6
Cells now charged and discharged several times until brought to a steady working state.									
8 0	80	156·9	18	9 20	83·8	184·6	19	95·5	85·0
Rest of 16 days. *First* discharge and charge after rest.									
5 21	53·3	104·1	20	6 30	58·5	128·3	21	Ratio of first discharge *after* rest to last charge *before* rest 63·6	56·4
								Ratio of first discharge *after* rest to first charge *after* rest 91·1	81·1
Cells now charged and discharged several times until brought to steady working state.									
7 6	76	149·5	22	8 12	78·3	173·5	23	97·1	86·3

From Table B it will be seen that, in spite of the continued charging and discharging at the end of each rest, there is a steady falling off in the quantity capacity from 101·9 ampere-hours at the beginning to 76 ampere-hours at the end, and in the energy capacity from 201·7 watt-hours to 149·5 watt-hours. The quantity and energy efficiencies, 97·1 and 86·3 per cent. respectively, at the end are the same as at the beginning. Comparing the first discharge after each of the 16 days' rest with the last charge before the rest, there appears to be a loss of about 36 per cent. in the ampere-hours, and about 43 per cent. in the watt-hours; or, since the normal quantity and energy efficiencies for a discharge immediately following a charge are respectively 97 and 87 per cent., it follows that the rest of 16 days causes a loss of about 33 per cent. in the ampere-hours and about 30 per cent. in the watt-hours, in addition to the losses that normally occur on a charging immediately followed by a discharging.

From all that precedes, it follows that the previous history of an accumulator produces an enormous effect on its efficiency. If, for example, an E.P.S. accumulator be over and over again carried round the cycle of being charged up to 2·4 volts per cell and discharged down to 1·8 volts per cell, the charging and discharging currents being the maximum allowed by the makers—viz., 0·026 ampere per square inch in charging, and 0·029 ampere per square inch in discharging—the "working efficiency" thus obtained may be 97 per cent. for the ampere-hours and 87 per cent. for the watt-hours. If, on the contrary, the cell be constantly charged up before being tested, then for the first few charges and discharges between the above limits, and with same current density in charging and discharging even the energy efficiency may be as high as 93 per cent.; whereas, if the accumulator has been left for some weeks, then, although it was left charged, the energy efficiency for the first few charges and discharges will be as low as 70 per cent.

While, on the one hand, our tests show that continued rests of a charged accumulator appear to be far more serious for the accumulator than we had previously imagined, the working efficiency appears to be higher than has hitherto been supposed, since we believe that about 84 per cent. efficiency in the watt-hours is all that the advocates of accumulators have claimed for them.

The smallness of the first discharge after a rest might be due either to a kind of electric short-circuiting and dissipation of the energy, or to some change in the character of the active material converting the energy perhaps directly into heat, or to some of the active material having become disconnected from the plates during the rest and having fallen down to the bottom of the cell. The smallness of the first charge subsequently to the first discharge after the rest shows that mere electrical leakage during that time has not been the cause of the loss of energy, while the steady increase in the storage capacity brought about by a series of charges and discharges tends to show that rest brings about some change in the nature of the active material.

In all the tests in which the results are given in the preceding table the charge and discharge were, as already stated, terminated when the P.D. per cell reached a fixed value; it is, therefore, possible that the apparent falling off in the capacity of the cells to store energy may be due to a change in the resistance of the cells produced by the rest. For a change in the resistance of the cells will change the terminal P.D. for a given current flowing through the cells without there being any necessary change in the storage capacity.

It is, therefore, interesting to study the variations in the shapes of the P.D. curves 8 to 23. First, as regards the charge curves, 9 and 11 are convex everywhere to the axis of time except just when the charging is commenced; whereas 13, the steady working charge curve after the second rest, rises much more rapidly when the P.D. cell is about 2·3 volts than is the case in the other two curves, then bends over and becomes concave to the axis of time. This peculiarity in curve 13 is, we notice, not very striking in the small reproduction of this curve in the text, but in the original curves as plotted on large sheets of squared paper from the results of the tests, the difference between curves 11 and 13 is very noticeable.

The following list gives the time in hours and minutes from the commencement of the charging when the P.D. per cell reaches 2·2 volts:

Curve 9...7h. 14m...Steady working charge before rests.
,, 11...7h. 32m... ,, ,, after first rest.
,, 13...7h. 10m... ,, ,, after second rest.
,, 15...5h. 36m... ,, ,, after third rest.
,, 17...3h. 54m...First charge after fourth rest.
,, 19...5h. 43m...Steady working charge after fourth rest.
,, 21...4h. 50m...First charge after fifth rest.
,, 23...4h. 40m...Steady working charge after fifth rest.

It is clear, then, that the effect of a series of rests is to cause the P.D. to rise much more rapidly in subsequent charges, and the time curve rise of P.D. still remains unusually steep, although at the end of every rest there was a prolonged and uninterrupted series of charges and discharges.

Curves 16 and 20, which give the values of the P.D. for the first discharges after the fourth and fifth rest, show that for the first hour from the beginning of each of these discharges the P.D. rises instead of falling, as is the case in normal discharges.

If the rapid fall of P.D. at the commencement of a discharge be due to a disappearance of gases occluded in the plates, as some have supposed—or if, as Dr. Gladstone and Mr. W. Hibbert imagine, the charging of a cell causes the acid round the positive plate to become denser than that round the negative, and the mixing of the denser and less dense acid at the commencement of the discharge causes the P.D. to fall—then the absence of this fall at the beginning of a discharge after a long rest would be explained; but neither of these theories would apparently explain the rise of the P.D. obtained by us at the commencement of a discharge after a long rest. Indeed, the fact that it required two discharges and two charges after long rests before the discharge curve (the third after the rest) acquired its normal form, tends to show that this rise of P.D. at the commencement of the first discharge after a long rest is due to some other cause.

Again, Prof. Duncan and Mr. H. Wiegand have shown in their communication that the diffusivity of the sulphuric acid into the plugs is greatest at the end of the charge, and least at the end of the discharge. Hence, if it be the diffusing out of the strong sulphuric acid from the plugs of the positive plate that causes the rapid fall of E.M.F. on breaking the charging circuit at the end of a charge (see Figs. 3, 4, and 11), one would hardly expect that it would be at the end of the discharge, when the diffusivity of the acid in the plugs was a minimum, that the rise of E.M.F. on breaking the discharging circuit would be most rapid, but that numerous experiments have shown us to be the case. In fact, curve No. 8, Fig. 11, shows that towards the end of the charge the E.M.F. falls from 2·298 to 2·274 volts in 20 seconds after breaking the charging circuit, and similar curves that we have drawn from our experiments on the time rise of E.M.F. on breaking the discharging circuit show that towards the end of the discharge the E.M.F. rises from 1·951 to 1·970 volts in 20 seconds, the latter rate of rise being almost exactly equal to the former rate of fall.

All the rests already referred to occurred when the cells were fully charged; but before these long rests took place the cells when in their normal state were on one occasion allowed to remain discharged for 34 minutes, with the following result:

Cells in Normal State.

Time taken to complete—

	Charging	11h. 38m.
Discharging	10h. 10m.	
	Next „	11h. 37m.
Next „	10h. 12m.	
	Next „	11h. 37m.
Next „	10h. 11m.	

Cells here remained discharged for 34 minutes.

First charging after rest, 11h. 50m.

First discharging after rest, 10h. 15m.

Next charging after rest, 11h. 42m.

These results emphasise the fact that accumulators are damaged if left discharged even for a short time, and it was for this reason that during the whole of this investigation the cells were never left discharged for a longer time than was necessary to change over the connections from discharge to charge, except on this one occasion when it was desired to ascertain the magnitude of the change produced by leaving the cells discharged for a short time.

It is interesting to notice that the effect of discharging cells too low, or of leaving them discharged, is to increase the times required for the subsequent chargings, whereas the effect of leaving them charged is to diminish the times required for the next chargings.

VIII.—Chemical Action.

Dr. Frankland has shown that probably the discharge of an ordinary accumulator is accompanied by the formation of one or other, or both, of the new lead salts which he has isolated, and which have the formulæ ($Pb_3S_2O_{10}$) and ($Pb_5S_3O_{14}$) respectively. And he concludes that, in view of the great difficulty of electrolytically splitting up the well-known white sulphate of lead ($PbSO_4$), this sulphate is not formed in the ordinary discharge of the accumulator, and is only produced when the cell begins "to sulphate."*

Prof. W. Kohlrausch and C. Heim, however, show in their paper already referred to that the observed variations in the specific gravity of the liquid during charge and discharge agree well with the very simple chemical actions:

Charge.

Positive plate—

$$PbSO_4 + 2\ H_2O + SO_4 = PbO_2 + 2\ H_2SO_4.$$

Negative plate—

$$PbSO_4 + H_2 = Pb + H_2SO_4.$$

Discharge.

Positive plate—

$$PbO_2 + H_2SO_4 + H_2 = PbSO_4 + 2\ H_2O.$$

Negative plate—

$$Pb + SO_4 = PbSO_4.$$

It is to be noticed, however, that the falling off in the specific gravity during discharge is merely a test of the amount of H_2SO_4 that is converted into H_2O, and affords no criterion as to what sulphate of lead is formed by the SO_3 liberated.

During our investigation we observed the variation in the specific gravity of the liquid during about 100 charges and discharges, and the mean of this large number of the fairly consistent results that we obtained showed that, with the accumulators we were testing, the variation in density per ampere-hour was about 0·000232. This result is probably right to within 5 per cent., for our hydrometer would read accurately to about 0·001, which is about 5 per cent. of 0·03, the total change in specific gravity observed during the discharge; and, therefore, as each result is correct to something like 5 per cent., the mean of a hundred results will certainly be correct to within 5 per cent.

On referring to tables of the density of dilute sulphuric acid, we find, by plotting the results, that between the limits we are concerned with—1·2 and 1·17—the change of density is directly proportional to the amount of SO_3 taken from the solution; and, further, that to produce a change in density of 0·01 at 15deg. C., it requires that one gramme of dilute sulphuric acid of density 1·2 should give up 0·01268 of a gramme of SO_3. And as the liquid in each cell weighed about 10,490 grammes when the cell was charged and the density 1·2, it follows that the weight of SO_3 liberated per ampere-hour in each cell, when calculated from the variation in the specific gravity, must equal

$$\frac{0·000232}{0·01} \times 0·01268 \times 10{,}490 \text{ grammes,}$$

or 3·086 grammes.

Further, the electro-chemical equivalent of SO_3 is 0·000414 grammes per coulomb; and since lead sulphate is formed on both the positive and negative plates during the discharge, the weight of SO_3 taken out of the liquid per ampere-hour, when calculated from the electro-chemical equivalent of SO_3, must be

$$2 \times 3{,}600 \times 0·000414 = 3·041 \text{ grammes.}$$

These two results show a close agreement. At the same time it is to be noticed that not merely does the amount of SO_3 liberated per ampere-hour come out somewhat higher when calculated from the mean change in the specific gravity than when calculated from the chemical equivalent, but the same result is obtained for each separate set of tests.

(To be continued.)

* "Contributions to the Chemistry of Storage Cells," *Proc. Royal Society*, vol. xlvi., 1889, p. 304.

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Specimen copies of the paper will be sent on request.

LEGAL MATTERS.

In this issue we have made an innovation in technical literature which we trust will be favourably received. Another column contains what may well be termed counsel's opinion upon a legal question, for the case has been submitted to a legal authority, with a request to give the state of the law on the matter. It will be well to recall the whole case. During the present year the inspector for the Weybridge authorities ordered some additional lamps to be erected, and Messrs. Laing, Wharton, and Down, the contractors for the supply, required facilities for erecting the necessary overhead wires. On receiving the order, therefore, they naturally proceeded to obtain what they deemed the requisite authority, and went to Mr. Eldridge, the highway surveyor, asking leave to cut certain trees that interfered with the wires. Mr. Eldridge therefore wrote a letter in which he said, "I hereby give you permission to cut the trees in St. George's-avenue on condition that you cut no more than is absolutely necessary." Upon receiving this—as it was thought sufficient authority — the work proceeded, the boughs were cut, and the damage done. Mr. Horace Avory, Q.C., to whom the trees belonged, commenced an action which resulted in the defendants ultimately pleading guilty. Mr. Avory pressed for a heavy penalty, but the magistrates took a different view and considered the case one for a small penalty. To the outsider the magistrates' view seems the just one. Although an Englishman is supposed to know the laws that govern the country, it may be presumed that few know aught of them, and in such a case would rely upon the surveyor knowing his own powers. Time and again have railway authorities proceeded against travellers for infringing by-laws which they are supposed to know, but of which they are profoundly ignorant, with the result that judges have almost always been favourably disposed to the traveller.

The question of overhanging trees interfering with wires is of interest to telegraphists, telephonists, transmitters of power, as well as to suppliers of electric light, and, so far as we can gather, till this case arose at Weybridge, no authoritative decision has been given on the subject. Upon the appearance of our note some time since, we received some correspondence upon the subject, suggesting that we should be doing a service by obtaining legal opinion. In pursuance of the suggestion made the article above referred to appears, from which it will be gathered that unless there is a special Act in force, it is illegal to meddle with trees in cases similar to the one under discussion.

In the majority of cases wherein legal opinion is sought, a newspaper is not a suitable medium for publicity; but there are cases of a very wide-spread interest, and such cases we shall be glad to receive

and to submit to counsel, with the view of publishing the opinion given.

THE LINEFF SYSTEM.

A good deal of interest and some correspondence has been caused by the publicity given to the experimental line of Mr. Lineff at the depot of the West Metropolitan Tramway. The report of Mr. Gisbert Kapp dealing with the system concludes with the remark, "I have come to the conclusion that the Lineff closed magnetic channel system is now ripe for practical application." This report deals first with the general description of the system, then points out that the car can, when running at full speed, be stopped within a distance of nine feet, and that the charged region of the insulated rail can be restricted to about nine feet on each side of the centre of the car. This charged part is wholly underneath the car, indeed, leaves a little less than two feet under the car at each end free, so that all the line accessible to pedestrians or to animals is uncharged and cannot give a shock. He finds the collection of current so arranged as to give no sparking, and the magnetic picking-up gear perfectly reliable both on a straight line and on a branch crossing. With regard to the economy of the system, he comes to the conclusion that the "total amount of steam power required at the station would, with storage cars, be about double that required by the Lineff system." It is quite evident from this report that Mr. Kapp knew nothing of Mr. Holroyd Smith's claims. Inventors are exceedingly chary of giving information—hence they frequently lose credit for what they have done. Mr. Kapp, on the question of novelty, says:

"With regard to the novelty of the Lineff magnetic conductor, I may add that although magnetic action has been used before by several inventors for actuating switches which establish electrical contact between a sealed main and separated lengths of surface rails, yet the idea of a continuous magnetic conductor forming so to say one single switch for the whole line is entirely novel and strikingly simple. The arrangement of magnetic rails on the hit and miss principle is also entirely new, and secures a great economy in the energy necessary to effect the attraction of the continuous magnetic conductor. This part of the invention especially has been worked out with great skill and care, as is amply testified by the good results obtained under the very unfavourable conditions imposed by the necessities of road traffic and by other mechanical considerations. The fact of having one set of magnetic rails only exposed on the surface, each length in turn becoming of north and south polarity, is novel, and will greatly help the adoption of this system in preference to those where two sets of exposed rails are required to close the magnetic circuit. The arrangement of blind rail, which performs the same office as if it were on the surface of the road and under the direct influence of the magnet pole, is very ingenious and effective."

The appendix to the report gives the figures and experiments upon which the conclusions are based, but this, which we purpose to give verbatim, must be left to another issue.

CORRESPONDENCE.

FIRE OFFICE RULES.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—In reply to Mr. J. B. Verity's letter in your last issue asking what is to be done to meet the various requirements of the insurance companies, I should like to suggest that the best way to avoid trouble is to carry out all installations in accordance with the Phœnix Fire Office rules, which are so well known and understood.

I do not think that any other office would object to work if carried out in this way, as it is well known that the Phœnix rules are the most complete and also the strictest. Surely they cover all other rules, though the latter do in many cases differ inasmuch as they are more lenient, and often do not ask for such good material as the Phœnix, but I do not think an inspector would object on this score. I always carry out my contracts in this way quite regardless whether Mr. Heaphy will inspect the work or any other surveyor, and have never experienced any difficulty with the other offices.

It is of course a great misfortune that there is not a *standard* set of rules for contractors to work to, as endless trouble might be thus saved. I think the rules of the Institution of Electrical Engineers would have to be considerably revised before they could be accepted as a standard.—Yours, etc., F. GREENE HOWARD.

18, Berners-street, W., 20th July, 1890.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—May I point out to Mr. Verity, through the medium of your columns, that the remedy he suggests for what he finds to be a great hardship is not likely to lessen his troubles but rather to increase them by the introduction of yet another authority, who has the sole merit of being impersonal and correspondingly vague.

It is not at all probable that the fire offices will forego their right to frame rules and do their best to enforce them, as it is proper both for the protection of their own and the public interests they should. I think that if contractors continue to carry out their work in accordance with the Phœnix rules they will find them to meet all the requirements of the rules of the other offices. At least, that is my experience.

Of course, Mr. Verity shares with other contractors the desire to support any regulations likely to act as a check on bad work, which has always been so harmful to the progress of electric lighting, and which the above rules have done so much to prevent.—Yours, etc.,

THOS. O. BELSHAW.

55, Victoria-street, S.W., July 24, 1890.

THE LINEFF TRAMWAY SYSTEM.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I do not wish to enter into a prolonged correspondence with Mr. Lineff, but as he has formed a wrong conclusion from my letter, others may have done the same; let me, therefore, be more explicit. I used the flat strip in 1886, and do not sanction its adoption by the Lineff Syndicate.

I found the "snake" preferable to the flat strip; it was not a failure. My articulated contact-maker or "snake" was not confined to a spiral wire, but, as stated in my letter of the 7th, its "anatomy was of varied form."

My tests were not mere models, but extended to full-sized apparatus, and finally resulted in a line three times 75 yards long, on which ran a full-sized car, seating 32 passengers.

I am sorry that I mistook the brushes for pins in the magnetic collector; the arrangement shown, however, is just as bad for one as the other. My error, resulting from an imperfect illustration, ought to have saved him from his amusing dissertation on AA, BB.

I do not presume to question Mr. Lineff's claim to superior knowledge, seeing that he has confined his "six months' painstaking work" to the flat strip, but having tried both I prefer the "snake" to the "tape-worm," and probably when Mr. Lineff has completed my cycle of experiments he will come to the same conclusion as myself—viz., that the work can be better accomplished another way.

That Mr. Lineff has carefully searched my "numerous patents," and also those of several others, is evident from his own Blue-books, and hardly needed a public statement on his part to that effect.

Finally, I am quite prepared to contract for the construction of tram lines on the magnetic attraction system.—Yours, etc., M. HOLROYD SMITH.

Royal Insurance-buildings, Crossley-street,
Halifax, July 19, 1890.

THE MEETING OF THE INSTITUTION AT EDINBURGH.

(Concluded from page 55.)

In the afternoon, on Tuesday, the party visited the telpher line. This line, situated to one side of the main building, and erected over some spare land, proved to be a most interesting and amusing affair. The system, of course, as is well known, has been adapted more for goods than for passenger traffic. Here it was erected for passengers, both to give them the experience and to indicate how transfer of goods or persons can be arranged. The line runs alongside a stand, at which travellers can mount. The cars are like a single outside 'bus seat, face to face, and two, or sometimes three, of such sets of seats are in each car. The cars are suspended, and swing from the rails above. At the ends these are fixed, but for the main portion of the line they run up and down, being steel ropes stretched from pole to pole. The motor itself also hangs suspended, geared by steel chains to the driving-wheel. The motor revolves with rather a rattling noise, owing to the steel gearing, and slowly creeps around, climbing up and down the swaying lines in a gruesome kind of manner—a cross between a parachute and a palanquin. The line curves up and down and in and out, and rises at the further end until it is some 30ft. or 40ft. high. Here the thing stopped, we imagined from loss of connection, and passengers began to wonder however they should get down. Tales of sundry travellers having had ignominiously to climb down by ladders came into our minds, when it started a moment, stopped, and started again; the switchman had us at his mercy, and was showing it. The telpher then merrily rattled along back again, straining at its load like a Belgian dog at its carriage, and drew up gently at the platform after quite an exciting journey through mid air.

The original documents, alluded to by Dr. Walmsley in his paper, were then inspected. These went to prove that the original idea of the electric telegraph was first proposed by Charles Morrison, of Renfrew, surgeon, in 1753, whose idea of 25 wires, one for each letter, to electrify little pith balls or pieces of paper, lettered, was shown in a commemorative tablet; in this the worthy inventor's head is shown in back view, little being known of his personality save from this early suggestion for communication at distances by electricity. The ingenious method of duplex pneumatic tubes was next seen and appreciated mostly by the members having to do with post office work. In this an electric arrangement of magnetic catches causes the pneumatic tubes to become charged automatically from the Westinghouse pump instantaneously on receipt of one parcel, so that the next is immediately sucked up and despatched without loss of time or need of attention. The old instruments of the Eastern Telegraph Company were inspected, and messages obtained upon the second original Thomson syphon recorder. The newest applications of electric signalling, invented and introduced by Mr. Spagnoletti on the Great Western Railway, were explained and worked by the inventor.

The members then spent the rest of the afternoon in inspecting the fine show of driving machinery and electrical apparatus down the main part of the Machinery Hall—the Galloway boilers, magnificent Robey 350 h.p. twin cylinder engines, driving a really splendid show of Brush dynamos and apparatus, used for lighting the exhibition and grounds. The Brush Company have also a fine stand, with the details of a 75,000-watt Mordey alternator in pieces, which came in for a good deal of attention. Of the large shows, the Electric Construction Corporation and the Edison-Swan Company also hold first places. In the first a full-sized electric car (the car by the Midland Carriage Works, Shrewsbury), as now running at Birmingham, stands in all the glory of new and finished workmanship; 18,000-watt dynamos and large motors are there; E.P.S. cells were of course *en evidence*, and a complete set of Sprague car gearing, with trolley, were seen as used in America. In the Edison-Swan Company's stand a striking show of lamps was passed, the most noticeable being the multiple 2,000-c.p. 100-volt incandescent lamps. The General Electric Traction Company have Immisch motors, here, there, and everywhere, all over the exhibition, drilling rocks, running fans, setting phonographs and other machines in motion, besides the electric launches—a favourite and much patronised practical achievement. The India Rubber Company's large Silvertown dynamo, driven by a Globe automatic engine, has a solid and handsome appearance.

Of the Northern firms, several were noticed as specially fine displays. Messrs. King, Brown, and Co., working with Messrs. Brown and Co. for the engines, have an imposing exhibition of dynamos and electric light. The firm is evidently in the front of electrical engineering, and is as capable of turning out large and well-finished work as the large London firms. Mr. Rankin Kennedy and Mr. Wilson Hartnell have excellent exhibits. The exhibit of Messrs. Napier, Prentice, and Co., of Stowmarket, came in for a good deal of attention, both on account of some large and fine dynamos and a special balanced high-speed engine shown by them, made by Easton and Anderson, for ship lighting.

The Woodside Electric Company's "Woodside" engine, "Woodside" dynamos, and "Woodside" arc and super-incandescent lamp were another Northern exhibit of great merit. The stand of Messrs. Ernest Scott and Co., of Newcastle was noticeable; and Paterson and Cooper; Laurence, Paris, and Scott; Ronald and Scott; Priestman's oil engines; Faraday's fittings; Poole and White's accessories; Latimer Clark's immense search-light and stand of instruments, were all visited. Others we have more extensively dealt with elsewhere were viewed. Without doubt the visitors felt and expressed their feelings that the electrical section was a worthy exhibition of electrical progress—far finer, indeed, than they had been led to expect.

THE CONVERSAZIONE.

In the evening a conversazione was held by the executive council of the exhibition in honour of the visit of the electrical engineers, in the Grand Hall. There was a large and fashionable assembly of some 400 or 500 people, and among those present, besides the electric notabilities, were Lord Kingsburgh, Sir Thomas Clark, Prof. Chrystal, Col. Malcolm, C.B., Dr. Stevenson Macadam, F. Ogilvie, Esq. (president of the Heriot-Watt College), Wallace Bruce, Esq. (American consul), and many other Edinburgh city bailies and officials.

Sir Thomas Clark, in welcoming the members of the Institution, said this was the largest body of engineers which had ever visited any city out of London, and it was to the honour of the city and the exhibition that they were there in such force.

Lord Kingsburgh said that some of the pleasantest associations of his life was connected with the electrical engineers in this country and abroad, extending over a period of 15 or 16 years, and he could assure his *confrères*

that they would find a firm and more complete selection of interesting appliances than ever they had found before in the exhibition where they were met. As citizens of Edinburgh they welcomed the members of the Institution, and thanked them for one thing especially, and that was bringing good weather. They had been very much under the damp for some considerable time, which was a state of things very much against the success of electricity. They had brought a dry atmosphere, which was the main thing in the conducting of electricity. He trusted they would enjoy their visit, and if the executive could do anything to contribute to their comfort they would do so most heartily.

Mr. A. R. Bennett, as convener of the Electric and Lighting Committee, said the prosperity which the electrical trades had experienced during the past two or three years had probably prevented the exhibition from being so complete as they would wished, yet he still could say that they had presented in Edinburgh the most complete and largest exhibition ever held in Great Britain.

Dr. Hopkinson thanked the Executive Council for the kindly welcome extended to them.

Mr. Preece believed there was no exhibition during the past 10 years purporting to be electrical which he had not visited, but he could say this—that there was not one which he or any member of the Electrical Institution had visited with which they had been more agreeably surprised than that of Edinburgh, a statement which was loudly applauded.

A very interesting hour or two was then spent in conversations, introductions, and the comparing of notes, while the visitors also inspected some special exhibits which were brought together for their interest. The Post Office sent an exhibit of telegraph instruments, and these were put into communication with Aberdeen, with Arendel (Norway), and with Christiania. Sir Thomas Clark sent messages to the King of Sweden and to the Postmaster-General, as follows:

To the King of Sweden, Stockholm.

On the occasion of the visit of the Institution of Electrical Engineers to the Edinburgh Exhibition, direct telegraphic communication is established with Scandinavia. On behalf of the executive council, I offer your Majesty very respectful salutation.—Sir Thos. Clark.

To Mr. H. C. Raikes, Postmaster-General, London.

On the occasion of the visit of the Institute of Electrical Engineers, on behalf of the executive council of the Edinburgh Exhibition, I thank you sincerely for the very fine exhibit of telegraphic apparatus contributed by the Post Office.—Sent by Sir Thos. Clark, chairman of the executive council.

An enquiry as to the weather and time in Sweden was received at "10.10," and the answer "very foggy" was returned to Edinburgh at 9.20. The telephones, by the kindness of Mr. Bennett, were connected up to Galashiels, 40 miles away, and Dundee, 109 miles, and music was transmitted with great clearness this distance. Sensitive flames, shown by Mr. W. Hume, showing the vibrations at different tones afforded much interest; and a reflecting galvanometer of special design, by Dr. Milne Murray, of the Edinburgh University, were so arranged as to show the physiological current from the body by taking the ends of the wires in the fingers. A real old globe frictional machine, as illustrated by Dr. Priestley, was shown by Mr. Hugh Auld. Mr. Bennett had some most interesting pieces of apparatus which he terms the "Radioscope," of which he will let us know more later, upon the principle of Crookes's radiometers, but in which one of the essential parts of the latter—the vacuum—was absent. The little blackened vanes, when covered by a heated tin cylinder, revolved in air, and also when covered by a core cylinder and a lamp was placed near, other forms being large cup-shaped pieces of thin tissue paper, which were kept in rotation by heat radiation. In the phonograph-room, Edison's phonograph was hard at work singing, whistling, talking, with more or less emphasis and distinctness, and the commercial uses of it were attempted to be illustrated by operators setting type and type-writing from its dictation. The type setter was driven by a little Immisch motor. During the evening some boy bagpipers displayed their talents to the awestruck and admiring Southrons. A very enjoyable evening was spent, and the Edinburgh executive and the members of the Institution had a most agreeable opportunity of becoming well acquainted with each other.

WEDNESDAY'S PROCEEDINGS.

The second day was opened at 10.30 in the morning by the reading of the paper by Prof. Ayrton and Messrs. C. G. Lamb, E. W. Smith, and M. W. Woods, of the Central Institution, on "The Working Efficiency of Secondary Cells." This paper, which may not unjustly be said to be an epoch-making paper in accumulator work, was listened to with the keenest interest, and was a worthy paper for an important meeting of the Institution, held 400 miles away, at Edinburgh. Prof. Ayrton unfortunately was unable to be present, and the paper was read, or rather fully abstracted, and each of its points dwelt upon in a very clear and able manner by Mr. Lamb. The paper itself we are giving elsewhere in full, and it will well repay the closest attention of those readers who were not fortunate enough to be present. Those, indeed, who did hear it read, will require time and consideration to fully digest what is the result of over a year and a half of very close and careful experiment and observation.

The main outcome of the paper is this: that the efficiency of the storage cell has by the public and the electrical profession been much underrated; that 80, 82, or even 84 per cent. return in energy efficiency are not too much to expect; that tests made upon storage cells without knowing their previous history are fallacious—to obtain correct results the authors ran the cells for some weeks till the charge and discharge curves time after time were coincident before taking their observations; that the loss of energy in the storage cell can be greatly traced to the loss due to the actual rise of temperature in charge and discharge, and the consequent loss of heat by convection and radiation—means to lessen this, of course, would increase the efficiency; that this increase of temperature takes place in two distinct ways, indicating two chemical actions, and that light may be thrown on the chemical action of storage cells thereby; that these careful observations will enable us to obtain the life history of the storage cell from its first formation to its death; and that the analysis of the plates taken out and broken up at times of various charge and discharge, now being undertaken by the authors as the subject of a further paper, will lend us valuable aid in determining the exact chemical action which takes place.

The historical records of tests of secondary cells previously undertaken was first given. The description of a most ingenious arrangement of resistance, shunts, motors, and contacts, etc., for the absolutely automatic charge at constant current, and discharge at constant current immediately changing over when full charge is obtained, received the heartiest applause of the meeting for the care and skill with which these had been devised and arranged.

In the discussion which ensued members were evidently unwilling to enter into much discussion of a paper which really required careful thought and digestion. Mr. Preece thanked the authors for the paper, and Prof. Perry said that all he could say would be old notions criticising the new ones. He thought it would marvellously clear our notions of the storage cell. He had himself in early days blindly tested a charged storage cell from the maker, and soon found the energy given out bore little relation to that he put in for a first charge—he need hardly say he had not published the results. He expressed great admiration for the ingenuity used in the construction of the apparatus undertaken for the good of the profession, and from which the designers could expect no commercial return. His only objection to the paper was that no distinction had been made between back E.M.F. and resistance: it was a thing that still remained to clear up. Mr. Kapp said he felt the impossibility of adequately discussing a paper which had taken one and a half year's study, and proposed the discussion should be carried over till the London meeting. Lord Bury spoke as to the practical results from storage cells, and considered they could be relied upon to a far greater extent than outside persons were disposed to believe. Mr. Barber-Starkey gave some particulars as to the devising of his idea of plaster of Paris and sawdust between the plates of the accumulators to keep the plugs from falling out. He said that two and a half parts of

fine sawdust to one of plaster of Paris was the proportion he had used on his own cells. Mr. Frazer spoke upon the diminution of internal resistance when accumulators were discharged quickly, and gave it as the result of his experience that the internal resistance of a storage cell was not constant, but decreased in inverse proportion to the discharge. Mr. Preece reminded Mr. Frazer that he had already pointed this out in a paper read in 1884. Mr. Frazer also suggested that experiments should be made not with one or two but with several hundred cells, as they varied much among themselves. He himself had tested 2,400 cells within the last year. With regard to the plaster of Paris, he had tested this practically at Barking. He had first tried four cells with a mixture of two of plaster and one of fine sawdust. Care was necessary to get the proper distribution of sawdust. He had found that the increase in internal resistance was small—5 or 6 per cent. In weight it was smaller still, the cell of 104lb. weighing afterwards with almost the same quantity of liquid only 108lb. He had then prepared a battery of 96 cells, and these had been in use for three months. The only fault was the loss due to increase of resistance, which in time, reckoned in current expended, became considerable. The difficulty in charging was also a trouble, as the plastered set required more electrical pressure to charge than the others, and it was not likely a resistance would be inserted in the other 11 sets to equalise the charge. M. Hospitalier then described an ingenious method of obtaining the value of E – V directly, devised by M. Roux, by means of condensers and a ballistic galvanometer. Mr. H. Swan suggested that as one of the chief present uses of accumulators was for traction, the tests for cells for this purpose should be made with the necessary conditions reproduced by vibrating stands, as the efficiency, be it ever so high when still, would necessarily be low if the plugs fell out in actual working, as it was understood they did on the present cars. He alluded to the greater strength of the Reckenzaun plates, sets of which had been working for over four years on tramway work and the plates of which could be freely knocked about without damage. Mr. Preece considered that the authors of the paper would have done a great thing when they had induced electrical engineers to believe that the secondary cell was not such an inefficient machine as they had been used to imagine. He believed when this was acknowledged it would be seen that a very large field was open to them in the field of secondary generators for distribution. He alluded to the exploded idea that because the charge was made at 2·4 or 2·5 volts and the discharge 2 to 2·1 volts, therefore there necessarily was a loss of 25 per cent. The energy is the product of current and pressure, and the very fact that the makers state the cells are to be charged at three amperes per square inch and discharged at four amperes, might indicate that the idea was absurd. There was a certain loss of energy, and one source of this loss, the authors point out, was the loss of heat due to rise of temperature. It was satisfactory to find that high science and actual practice coincided; from practical reasons he had arrived at the conclusion that it was not good to discharge below 1·8 volt. His gardener took the greatest care of the cells, treated them like a child not to overfeed or starve them, and he had cells in his house, in perfect bright condition, which had lasted six years. Mr. Massey, however, asked if they were the same cells. Mr. Preece said no. But those he first had were now at the Post Office. He had tried every kind, and liked to have the latest at his house to test. Early specimens of Faure and Elwell-Parker cells, all kinds of E.P.S. he had tried in every new type, and he would take out his present cells and try others if anyone had a better kind to show him. One test he never omitted, and this was to take the density by hydrometer. With reference to Mr. Barber-Starkey's experiments, he had tried the carbonate for over two years, and now uses the electrolyte for 23L cells of the following proportions, out of 45 parts: 39 parts of water, 5 parts sulphuric acid, 1 part saturated solution of carbonate of soda. Cells so treated never show sign of sulphating, and remain perfectly bright. He alluded to the method of charging introduced by Mr. Edmunds, in which cells were charged for a few minutes in rotation automatically, and said he thought some automatic system of this kind would be the on eventually used in practice. The greatest loss of energy i charging secondary cells was the loss due to certain cells i a set becoming charged before others, and allowing th energy to dissipate uselessly. The loss was not so much i the low efficiency of the cells, but in the waste of th charging current. Mr. E. W. Smith replied to the discu sion, and a hearty vote of thanks to the joint authors te minated the morning's proceedings.

The whole party then, after lunch, went in a speci train to the Forth Bridge, and inspected with a vast intere this stupendous undertaking. The walk across among th immense tubes and girders took about half an hour, and th impression of immensity was deepened when the steame took them round about, in and out, under the huge canti levers, giving the visitors a lasting impression of thi wonder of the North.

The third day's paper was on "On Some Remarkabl Phenomena Observed whilst Experimenting with Electricit applied to Crookes's Radiometer," by Mr. A. R. Bennett dealing with the apparatus to which allusion has alread been made. In the afternoon an excursion was arrange by the executive council for the members in the electri launches on the Union Canal, which joins Edinburgh an Glasgow, the scenery of which is very beautiful, and alon the route of which are many places of much interest.

Great praise must be given to the executive for th hearty reception and admirable arrangements for the com fort and interest of their guests, and it may be mentione that several gentlemen of the executive council enter tained members of the Institution in the most cordial manner at their own private residences. The excursion t Edinburgh will long be remembered as constituting a mos pleasant and most interesting meeting of the Institution o Electrical Engineers.

OBSTRUCTION BY TREES TO OVERHEAD ELECTRIC WIRES.

A recent case has directed attention to the very important question—how far companies, in carrying electric wires along public roads, are justified in lopping trees which, whether growing upon or overhanging the highway, interfere with such wires?

We will first consider the rights of the public with regard to such trees, and then see in what respects companies engaged in undertakings of the kind specified occupy a peculiar position.

It has been settled law from a very early period that the soil of the road, as far as the centre, belongs *primâ facie*, to the adjoining landowners, and this ownership carries with it the right to everything growing upon and lying beneath the road—*e.g.*, trees and minerals. The public have merely a right to pass along the surface. If, therefore, any person interferes with such trees he does an injury to the adjoining owner, for which he may be proceeded against at law. But though this is undoubtedly so, yet there are certain restrictions upon this ownership. For instance, if the trees, whether growing upon or overhanging the road, amount to a public nuisance, the owner may be called upon to remove or lop them, and, if he neglects to do so, any person aggrieved may remove the obstruction with impunity. Under the Highway Act, 1835, the road surveyor can compel the removal of trees growing upon a public carriageway or cartway, or within 15ft. of the centre thereof, and the owner must clear them within 21 days after notice from the surveyor under a penalty of 10s. for each offence. But the trees cannot be sold as against the owner; above rights are to this extent preserved, while there are certain months in the year during which their removal cannot be insisted upon. Again, under the same Act, in the case of trees growing in private grounds but overhanging the road, the surveyor may require the owner to lop them if in the surveyor's opinion such trees by their shade or by withholding the access of sun and wind injure the road. But in this case the owner cannot be compelled to lop such trees if they are planted "for ornament or

shelter to any hop ground, house, building, or courtyard of the house."

Such being the position of the public with regard to the owners of the trees, what are the rights of companies engaged in the construction of telephonic or electric lighting works? We would first point out that, in the absence of any special statutory powers, such companies have only the ordinary rights of the public. For instance, in the recent case already referred to, we understand that the company (an electric lighting one) were only working under a license from the local authorities, and, consequently, could claim no exemption from their common law liability for any damage done by them. But, generally, telephone and electric lighting companies work under special Acts of Parliament, which, so far as they go, render their position different from that of ordinary members of the public. Armed with an Act of Parliament, these companies are, and properly so, statutory monopolists, having alone the right to carry out certain specified works, and being protected in doing what any ordinary individual could not do without liability to legal proceedings. In the construction of their works they must necessarily interfere with, and sometimes injuriously affect, private property. The special Acts contemplate and provide for these contingencies. But the companies are strictly enjoined thereby to do as little damage as possible, and to make proper compensation to all persons damnified. The companies may do whatever damage is unavoidable in the construction of works authorised by their special Acts, provided they adhere strictly to the lines laid down therein. But if they step beyond them they are no longer protected, but are in the same position as other members of the public, and liable, accordingly, for any extra damage, whether accidental or not. So long as they keep to the authorised works, and to the prescribed mode of carrying them out, they are protected in the manner indicated. If, for instance, an electric lighting company, in carrying their wires along a public road within the limits allowed by their statutory powers, find it impossible at any particular point to avoid trees, either growing upon or overhanging the road, they are justified in lopping them as far as may be necessary. But they must not lop more than is absolutely necessary, and must compensate the owners for the actual damage they may cause.

It is obvious that in disputes arising out of transactions of this nature it will always be a question of fact whether the lopping was excessive or not; this is unavoidable. But the disputes themselves may be greatly diminished if, on the one hand, the companies are careful to keep within their statutory limits, and, on the other, if private owners in asserting their rights do not capriciously throw obstacles in the way of public improvements, the benefits of which they share.

SOME CHIEF FEATURES, MAINLY ELECTRICAL, OF THE EDINBURGH INTERNATIONAL EXHIBITION, 1890.*

BY DR. WALMSLEY.

INTRODUCTION.

When requested by the Electrical Committee of the Executive Council to read a paper on the chief features of the exhibition at a meeting of the Institution of Electrical Engineers, my first feeling was that such a paper was unnecessary, as the members of the Institution are, as a body, thoroughly well posted up in such of the latest developments and applications of their science as are usually to be found in the courts of an exhibition. Then, again, the interval since the last exhibition in this city, in 1886, is so short, and has, moreover, been so well filled by several excellent exhibitions, both in Great Britain and on the Continent, including the magnificent display at Paris last year, that it seemed to me that it would be impossible to find sufficient material to form the substance of a paper worthy of the traditions of the Institution. On the other hand, since the Institution has done us the honour of holding an extraordinary general meeting 400 miles from its base of operations, it is only courteous that we should, however inadequately, give them some outline of what they have come so far to see. And, moreover, when I began to look into details I discovered some things which I thought were worthy of being brought under the notice of the Institution. Whether I was right in so thinking, or whether I have used a wise discrimination in my selection, I must leave my hearers to judge. In the following remarks I have purposely dwelt, from time to time, on the productions of exhibitors hailing from the North with more detail than I have devoted to their more Southern competitors. This I have done, not because I wished to make invidious comparisons, but because I thought such productions would probably be less familiar to our visitors. It is matter of common knowledge that some of the best-known Southern firms are not exhibiting, and this remark will explain the omission of all reference to some well-known electrical machines and apparatus. Though much to be regretted in the interests of our immediate neighbours and friends, this will not cause our Southern visitors much disappointment, as the absent apparatus is well known to them.

For convenience of reference I have divided my remarks under several distinctive heads, and without further preface shall proceed to consider these.

HISTORICAL.

The exhibition is particularly rich in interesting historical exhibits. The Railway Court would of itself be worthy of a fairly long journey to anyone who is open to the stimulating effect of comparing the splendid machines and equipments placed at the disposal of the travellers of to-day with the humble beginnings, not yet a century old, with which the young giant steam tentatively put forward his claims to serve them. But passing by this inviting subject the electrical antiquary will find much to occupy his thoughts. First and foremost there is exhibited close to the Post Office stall in the Machinery Hall the most important part of the documentary evidence on which rests the claim of Charles Morrison, of Greenock, to be the inventor of the electric telegraph. This consists of a copy of the *Scot's Magazine*, of February 1, 1753, laid open at the page containing a letter signed "C. M.," in which it is proposed to correspond between distant places by means of electricity. As is well known, the method suggested was that there should be a separate wire for each letter, and that pieces of paper or other light material bearing the actual characters should be caused to rise at either end of the wire by the attraction of electrified balls.

The originals of the letters which led Sir David Brewster to identify Charles Morrison, of Greenock, as the "C. M." of the *Scot's Magazine* are shown, and underneath is a photograph of a relief, modelled by Mr. Alexander Macmillan, a young student of Greenock. The relief itself, which is in the Watt Monument at Greenock, is about 2ft. square, and is an attempt to reproduce the actual conditions of Charles Morrison's experiment. For this purpose the artist visited Renfrew and also consulted the plates in contemporary works on electricity.

Close to, another memorial of telegraphic history is exhibited, consisting of a symbolically carved frame, enclosing part of a copy of the *Journal* of the Asiatic Society of Bengal for September, 1839. The pages exposed contain a paper by Sir Wm. O'Shaughnessy Brooke, describing experiments on a telegraph line 21 miles long, including 7,000ft. of river length. These are believed to be the first successful experiments on a line of that length. The receiving instruments used were sometimes galvanometers, sometimes induction coils, and it is curious to notice that the writer expresses a very strong preference for the physiological effect of the current as being the best adapted for the purpose of receiving messages.

On the Post Office stall itself there will be found many illustrations of the social effects due to cheap postage, which will be worthy of the attention of those who have not had the opportunity of seeing the recent fine exhibitions in London in connection with the Jubilee of the Penny Post. Turning to the electrical exhibits, a fairly continuous series of historical signalling instruments is shown, with old types of insulators and methods of jointing. An inspection of the resistance coils used by Wheatstone in 1838 should cause our younger "practical" electricians to reflect upon the debt they owe to the British Association Committee, and to the labours of pure scientists which have resulted in giving us a definite standard of resistance.

Perhaps the most interesting "historical" telegraphic instrument is, however, on the stand of the Eastern Telegraph Company. This is one of the original syphon recorders, whose invention by Sir William Thomson has done so much to make cable telegraphy a commercial success. The instrument shown is marked "No. 2," and is, therefore, presumably the second instrument manufactured. After 20 years' service it was invalided home to be laid on the shelf, as it was decided that it was not worth the cost of putting it in working order. Mr. Zobel, who is in charge of the exhibit of the company, has, however, by dint of great patience and perseverance, set the cripple on its legs again, and quite legible messages can now be received on it. Of its lineal descendant, "No. 300," which is on the same table, I shall have something more to say presently.

Another most interesting historical exhibit is shown inside the north corner of the screen surrounding the lighting dynamos in the Machinery Hall. It is the first magneto-electric machine actually used for electroplating. This machine, which some of my hearers may have previously seen at the Birmingham Exhibition, was built in 1844, having been patented two years earlier by I. S. Woolrich, of Birmingham. There are eight armature coils, with iron cores, rotating between the poles of four horseshoe permanent magnets. The coils are coupled in pairs by a plate on one side of the machine, and the other ends are brought to the sections of an eight-part commutator, from which the current is led off by brushes. Solid adjustable bars of iron are used to connect the poles of the magnet for the purpose of regulating the E.M.F. developed by more or less short-circuiting the magnetic flux.

*Paper read before the meeting of the Institution of Electrical Engineers at Edinburgh, July 16, 1890.

required to excite the field-magnets is 650 watts. The Tyne transformer used with the above is also exhibited. The core consists of a single closed magnetic circuit, and the primary coils occupy about three times the space of the secondary. The fuses are tin and lead respectively on porcelain bases, and the whole is enclosed in a cast-iron box as is now necessary.

The same firm also supply a continuous current to 200 ordinary 16-c.p. lamps, including all the lamps in the Railway Court and also lamps on various exhibitors' stalls in the Machinery Court. The dynamo used is a 15-kilowatt compound four-pole machine. The yokes of the field-magnets, which carry the exciting coils, are placed at an angle of 45deg. to the vertical, and the pole-pieces occupy the ends of a vertical and horizontal diameter. These pole-pieces embrace the armature core to its full depth. The advantage claimed for this design is that by removing four bolts the top half of the field-magnets may be readily lifted off, and the armature either taken out or examined and repaired *in situ*. The joint thus made in the magnetic circuit is along the lines of flow, and is therefore not objectionable magnetically. The armature is a well-built Gramme ring with a carefully designed commutator, and is well ventilated, as in many four-pole machines only two brushes are used.

The Woodside Electric Company exhibit some well-built D type dynamos, and some high candle-power glow lamps. Amongst the latter there is a 300 nominal candle-power lamp requiring 10 amperes at 65 volts, and a 500 nominal candle-power lamp which takes 10 amperes at 100 volts; both these are guaranteed to last 800 hours.

The Electric Construction Corporation exhibit the various ingenious automatic appliances used in their Chelsea stations in connection with their direct-current accumulator supply system. These have been recently described very fully in the columns of the technical press, but some of my hearers may be glad of the opportunity of inspecting the apparatus itself.

The Brush Electrical Engineering Company show a Mordey 100 h.p. alternator dissected, and Messrs. Rankin Kennedy and Co. exhibit direct and alternating current machinery, including an interesting alternating-current motor.

A neatly designed dynamo, with a large commutator, is shown by Messrs. Wilson Hartnell and Co., who also exhibit a neat switchboard with double-pole and single-pole switches and cut-outs.

Other well-known firms hailing from further south exhibit their various productions with which, however, I think my present hearers will be thoroughly familiar.

(To be continued.)

SOME EXPERIMENTS UPON ALTERNATING CURRENT APPARATUS.*

BY HARRIS J. RYAN.

(Concluded from page 58.)

The range of temperature that produced this change was 170deg. C. The magnetisation for each condition is the same, so that it is fair to assume that the E.M.F. setting up the Foucault currents is the same, and that, therefore, the energy dissipated by Foucault currents will diminish as the resistance of the iron is increased by the elevation of its temperature. This gives us a rough determination for the temperature coefficient of the iron to ·4 of 1 per cent. per degree centigrade, which agrees with Matthiessen's determination, and furnishes a fair check upon the conclusion just arrived at. The results of these experiments are represented graphically in Fig. 7.

The second interesting feature about the performance of Mr. Marks' apparatus lies in the fact that the ratio of primary to secondary turns was 3·2, while the ratio of primary to secondary E.M.F. varied from 4 to 8. In this it exhibited exceedingly bad regulation, so that by examination of the diagrams, Figs. 2, 4, 5, and 6, we can see in exaggerated form the trouble it is so hard to get rid of in transformers to be used for incandescent lighting. Any one of these diagrams shows that a large portion of the lines of magnetisation that was set up about the primary were not set up about the secondary. That is to say, the counter E.M.F. that is produced in the primary is due to the magnetisation through it that also took place through the secondary, plus the variation of magnetisation that was set up in its own air space, and that leaked by the secondary through the air. When the transformer furnishes current this difference becomes greater and greater because of the increased current in the primary, and the setting up of a counter magnetisation by the secondary current in its own air space that still further reduces the magnetisation through it.

Fig. 1* shows the primary disposed on one side and the secondary on the other side of the annular core. The insulation was produced by thick asbestos paper that produced large air spaces between the turns in which magnetisation was produced.

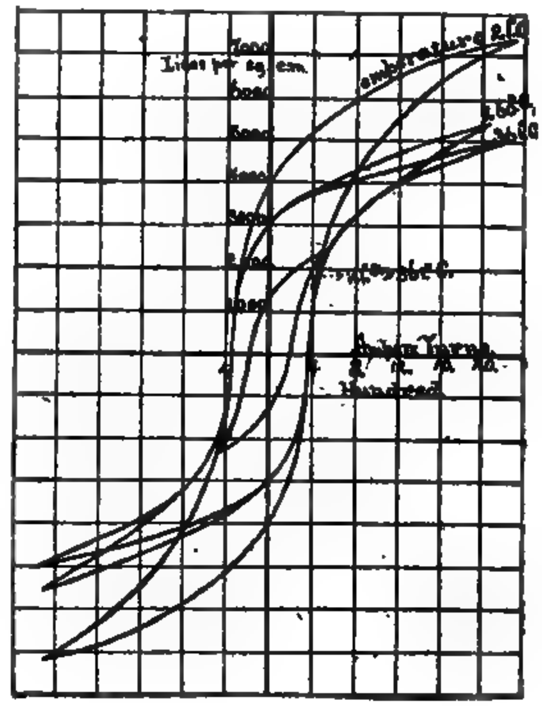


Fig. 7.

In Fig. 2, E.M.F. curve *b* is the counter E.M.F. in the primary produced by the magnetisation through it that also took place through the secondary, and which is obtained by multiplying the secondary E.M.F. by 3·2, the ratio of the turns. E.M.F. *c* is the curve of counter E.M.F. in the primary that was produced by magnetisation through the primary

Fig. 8.

that did not take place through the secondary. This is obtained by subtracting E.M.F. *b* from E.M.F. *a*. E.M.F. *c* is seen to be approximately proportional to the rate of change of the primary current, which suggests magnetisation that is set up through the primary that is proportional to the primary current, or that which is set up in the air, or in a magnetic circuit compounded of iron and air.

In the same figure the curves of magnetisation *a* and *b* are obtained graphically from the curves of E.M.F. *a* and *b* by the method shown in Fig. 3. This method is found to be fully as accurate and requires much less time and is more simplified than the analytic method making use of Fourier's theorem.

*Paper read before the American Institute of Electrical Engineers, June 17, 1890.

* Figs. 1 to 6 inclusive were given in our last issue.

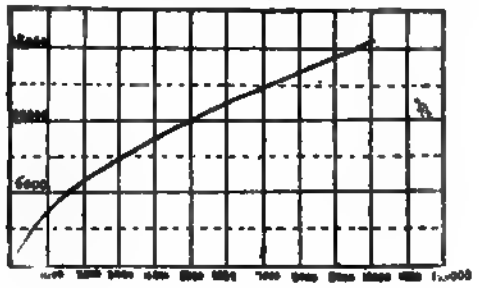
By subtracting b from a we obtain c, the curve of magnetisation that was produced through the primary and not through the secondary. This curve of magnetisation c is seen by the diagram to be of about the same form as the current curve, but to lag behind the latter, which indicates that it was magnetisation that was produced through air and air and iron.

Fig. 9.

During the discussion, at a recent meeting of the institute, the question was asked whether measurements of Foucault currents and hysteresis as separated from each other had ever been made.

There can be no doubt but that we do have separate determinations of those quantities when we have determined the energy dissipated in a magnetic circuit of iron by rapid cycles of magnetisation and demagnetisation, and the energy dissipated by static hysteresis for the same rapidity and degree of magnetic changes as determined from a Ewing card observed through slow magnetisation and demagnetisation.

Wrought-iron Hysteresis.



Ergs per cubic centimetre per second.

Fig. 10

The diagrams Figs. 8 and 9 are two good illustrations of such determinations. In Fig. 8 the outer card represents the card obtained from the exciting current and magnetisation curves taken carefully at 138 reversals per second from the 10-light transformers upon which the tests were made, that were communicated to the institute by the writer at the last December meeting. The inner card drawn in a full line in Fig. 8 is the Ewing card of static hysteresis. This transformer, on being taken apart, was found to have its discs insulated with paper, so that the statement made by the writer in December with regard to the lamination of this transformer was erroneous in this particular. Foucault currents should therefore be found to be quite absent, as the diagram in Fig. 8 indicates. A study of these cards does not reveal that which can be recognised as a trace of viscous hysteresis, and they differ only by an amount of Foucault current energy that is represented by a small current lagging approximately an eighth of a period behind the primary impressed E.M.F.

Fig. 11.

In Fig. 9 the outer card is deduced from the current and magnetisation curves that are represented in Fig. 12. These curves were obtained with 195 reversals per second

Fig. 12.

from a cast-iron ring 8·6 cms. in diameter, and 2·7 square cms. in cross-section, wound with 200 turns of wire that had a negligible resistance.

Fig. 13.

In Fig. 9 the inner card is the card of static hysteresis. In Fig. 12, the lower broken current curve is that of the exciting current curve drawn in from the inner card of Fig. 9. By subtracting this current from the one that was observed, we obtain the upper broken current curve, which is the current that exists to supply the Foucault current energy in the core. The point to be noticed from the two

extreme cases here taken up is that in each case the curve of current supplying the Foucault current energy is about one-eighth of a period behind the impressed E.M.F.

Messrs. Forhenbaugh and Sawyer, students in electrical engineering at Cornell University, made determinations, the results of which are given in Table III. of the amounts of energy that are taken up per cubic centimetre in wrought-iron wire cores of different degrees of lamination, at various degrees of magnetisation, and at different periodicities, in which the oxydised surface of the iron was depended upon for insulation. They made use of four iron wire rings, the mean diameter of each of which was 8·9 cms., and on each of which are wound 200 turns of wire that had a negligible resistance. Figs. 11 and 13 are given for illustrating the extreme variation in the character of the exciting current in going from the lowest to the highest degree of magnetisation.

TABLE III.

Coil. No. of wire. B. and S. G.	Area of coil sq. cms.	Periodicity.	Magnetisation per sq. cm.	Loss watts per cu. [illegible]
12	5	169	5,300	·18
"	"	177	8,560	·46
"	"	177	11,130	·75
16	4·9	173	6,000	·14
"	"	175	9,430	[illegible]
"	"	167	10,930	·43
"	"	93	7,250	·10
"	"	92	13,360	·41
"	"	45	13,000	·10
24	3·56	175	8,150	·19
"	"	[illegible]	8,760	·12
36	3·14	173	9,200	·16
"	"	173	14,900	[illegible]
"	"	173	18,000 app.	·48
"	"	96	10,700	·15
"	"	92	17,800	[illegible]
"	"	47	18,000 app.	·13
" Cast Iron	2·7	160	4,920	1·50

Diameter, 3·5 by 2·54.

The result shows, on account of the presence of Foucault currents to a larger extent for the higher degrees of magnetisation, a variation in losses as the square of the periodicity and the square of the magnetisation. The results obtained with the several cores at the periodicity of 175 reversals per second have been plotted in Fig. 14.

The card of No. 36 wire agrees closely with Ewing's determination of static hysteresis for moderately soft wrought iron, and is therefore entirely free from Foucault currents. It is interesting to note that for the cores of No. 36, No. 24, and No. 16, there is but little difference in the losses for degrees of magnetisation below 4,000 lines per square centimetre.

FIG. 14.

Likewise, for the higher degrees of magnetisation, it is seen that the loss is proportional to the magnetisation, as Ewing's results on static hysteresis, given in Fig. 10, indicate they should be. Fig. 13 shows the effect of compelling the magnetisation to be carried above the bend of the characteristic curve of the iron.

LEGAL INTELLIGENCE.

THE NORTHERN ELECTRIC WIRE AND CABLE COMPANY.

On Thursday, 17th July, Mr. Justice Kay heard an application on behalf of Mr. Edward William Hall, of Park House, Bradford, Yorkshire, to correct the register of the Northern Electric Wire and Cable Manufacturing Company, Limited, by removing his name as the holder of 160 shares.

Mr. Renshaw, Q.C. (with him Mr. Maidlow), said this was an application, under section 35 of the Act of 1862, to have the register of the company rectified by omitting the applicant's name from the list in respect of 160 shares which the company purported to have allotted to him, and for repayment of the sum of £80 and interest. The company was formed with a capital of £20,000, divided into 4,000 £5 shares, the certificate of incorporation being dated June 25, 1889. On this date a meeting of subscribers to the memorandum of association was held at half-past ten in the morning, when it was resolved that the contract for the sale and purchase of the business should be confirmed, and that certain shares be allotted, amongst others being the applicant's, though from the appearance of the minute it looked as if the number of the shares had been inserted at a subsequent period. That this must have been the case was proved by the fact that Mr. Hall had not then applied for shares, though he received a copy of the prospectus on May 29 from Blakey, Emmott, and Co., the vendors. On July 3 Mr. Hall applied for 160 shares, and paid thereon £80, and on July 4 the secretary wrote informing him that the shares had been allotted. At a meeting of the directors, held on July 29, the certificates were signed, but were not forwarded to Mr. Hall, and on August 14 he withdrew his application. On September 10 his solicitors wrote disclaiming all liability in respect of the shares, and on December 20 the directors passed a resolution forfeiting the shares. The learned counsel contended that the resolution allotting the shares was passed before the incorporation of the company, and was consequently invalid.

The **Clerk** who registered the company was called to state the circumstances and date of registration, but was unable to speak positively on this point.

Mr. Hayman, a clerk from Somerset House, gave evidence as to the practice in registering companies. The registration was dated from the day the papers were lodged, and from the stamps on the papers in question he had no doubt they were left on June 25.

Mr. Renshaw contended that as the minute book showed a meeting of subscribers on June 25 at 10.30 a.m., at which the allotment was purported to have been made, it was evident that the allotment was made before the company was incorporated.

Mr. Justice Kay said there was nothing to show how long the meeting lasted. He should not assume anything in favour of a man seeking to avoid a contract.

Mr. Renshaw said his case was that there never was a contract. At that time Mr. Hall had not made any application. He also submitted that four subscribers had not power to allot. No quorum had been appointed. It was admitted that the motive actuating the applicant in seeking to be relieved of the shares was dissatisfaction with the managing directors in connection with other matters, but that did not affect his legal rights.

Mr. Marten, Q.C. (with him Mr. Oswald), for the company, submitted that there was no substance in the objection made by Mr. Hall; the only irregularity suggested was that the allotment was made before the application was actually received.

His Lordship, without calling upon Mr. Renshaw to reply, said it seemed to him that in the present case there was no binding contract. He then went in detail through the facts of the case, and concluded by saying that the whole of the proceedings had been so grossly irregular that he must order the applicant's name to be removed from the register, and the £80 with interest to be repaid.

SHARP AND KENT v. DANE.

In the Westminster County Court, on Thursday, his Honour Judge Bayley had before him the case of Sharp and Kent *v.* Dane. The action was brought by Messrs. Sharp and Kent, electrical engineers, to recover damages against the defendant, John Dane, for leaving their employment without giving proper notice to quit, in accordance with the plaintiffs' printed rules.

The plaintiffs' manager was called and said the defendant was engaged about a year ago as an electric wireman. He was first employed as a time worker, but in January last he was re-engaged as a weekly servant at £1. 15s. a week. The defendant was aware of the printed rules, which provided that a week's notice should be given on either side. On June 26 last he refused to do any more work on the ground that he would not work under a foreman named Brittain, and as there was nothing more for him to do at the time he left work and never returned.

The defendant was called, and complained that he had been very shabbily treated by the firm, who still owed him for four and a half days' work. When he first worked for them he was paid by the hour, but was subsequently taken on as a weekly servant at £1. 15s. a week. He had to work very hard, and sometimes did as many as 90 hours' work in a week. He certainly did refuse to work under Brittain, but the plaintiffs were very slack at the time, and had nothing else for him to do.

His Honour said he failed to see how the plaintiffs had suffered any damage, therefore judgment would be for the nominal sum of 1s., but no costs would be allowed.

When he last addressed them he referred to the West Coast of Africa system as being fully completed, and he also expressed his opinion that this would have important results. He was glad to confirm that opinion on the present occasion. The African Direct Company were paying 4 per cent. and the West African Company were paying 5 per cent., and expected increases in both cases. They were now in a position to meet all the requirements in connection with the development of the Dark Continent, and he hoped they would be able to carry on their work in this direction, not only in the interests of civilisation, but in those of the shareholders also. Since the last meeting he had been to Egypt, and the result of his visit had been that they had settled their affairs in that country in such a satisfactory way that material benefit would result to the Company and advantage would also accrue to Egypt. At the recent Telegraph Conference in Paris the Company were ably represented, and he was bound to say that the representatives of the different Governments of Europe had given, on the whole, very fair consideration to the representations made at the conference on the part of the companies. He could say, without fear of contradiction, that their relations with the existing European Governments, so far as telegraph matters were concerned, never stood better than they did at the present time. He thought they had come out of the conference in a more satisfactory manner than they had come out of any previous conference. He had no hesitation in saying that the reductions in tariff which they had made in consequence of the conference would be recouped by increased traffic by their next meeting, or, at all events, before another year was out. He was glad also to say that their relations with India had been very materially improved at the conference. Since their last meeting an important change had been made in regard to the Australian tariffs, in connection with which they were going to make a remarkable reduction. The Eastern Extension Company were going to reduce their rates, and what that company did on the one side the Eastern Company had to support more or less on the other side. They were, therefore, party to an arrangement with the Eastern Extension Company, whereby the Australian tariff would be reduced from 9s. 4d. to 4s. a word, the Governments of these colonies guaranteeing to make good half the loss which might be sustained by this reduction. He thought that this arrangement should add materially to the value of the property. The reduction in the tariff would necessarily lead to a very considerable extension of their system generally. Their Red Sea cables had been in operation for about 20 years, and the Directors felt that they must prepare at once for that increased traffic. They had, therefore, decided to lay another cable in the Red Sea from Suez to Aden at a cost of at least £250,000. They thought it would be better if they paid for this cable mainly out of reserve fund. They had, therefore, on the present occasion increased the reserve fund considerably, so as not to add to their capital. He thought they were in a sound and satisfactory condition, and the amount they were carrying forward was very large. He concluded by moving the adoption of the report and the declaration of the dividend and bonus recommended.

The **Marquis of Tweeddale** seconded the motion.

Mr. Clarkson criticised the action of the Directors in laying so many cables, contending that it was unnecessary if they would adopt a certain cable instrument which, he said, was doing over 30 paid words per minute. He also criticised the policy of the Directors in other respects.

The **Chairman** said that a great deal of what Mr. Clarkson had said was ancient history, and he would merely say, in reply, that the property was being managed by the Directors in the best interests of the shareholders.

The resolution was adopted.

On the motion of **Mr. James Gibb**, seconded by **Mr. John Newton**, and supported by **Dr. Waller**, a vote expressing sincere condolence with the Chairman on account of his recent domestic bereavement was passed.

COMPANIES' REPORTS.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY, LIMITED.

Directors: James Staats Forbes, Esq. (chairman), Frederick Richards Leyland, Esq. (deputy-chairman), the Viscount Anson, Shelford Bidwell, Esq., F.R.S., and Ernest Villiers, Esq.

Seventh annual report of the Directors for the year ending 30th June, 1890.

The business of the Company has resulted in a credit balance of £61,115. 3s. 3d. Of this amount £12,371. 14s. 7d. has been absorbed by the payment of an interim dividend on the A shares, at the rate of 7 per cent. per annum for the first six months of the year. The Directors recommend the payment of the following dividends on the A shares, free of income tax, and to be distributed in accordance with clause 87 of the articles of association: (a) At the rate of 7 per cent. per annum for the half-year ending 30th June, 1890 (making 7 per cent. for the year). (*b*) Four per cent. in completion of payment of arrears of cumulative preference dividend for the year ending 30th June, 1884. (*c*) Four per cent. in respect of arrears of cumulative preference dividend for the year ending 30th June, 1885, which will absorb £40,649. 19s. 3d., leaving £8,093. 9s. 5d., which the Directors have carried to the reserve fund, in accordance with article 89 of articles of association. The Directors have been adding to the buildings and plant at the factory, so as to enable them to manufacture lamps in sufficient numbers to meet the demand which will arise as the supply companies extend their operations in London and other towns. Mr. Shelford Bidwell, F.R.S., retires from the Board, and offers himself for re-election as a director. The auditors, Messrs. Welton, Jones, and Co., retire, and are eligible for re-election.

PROFIT AND LOSS ACCOUNT FOR THE YEAR ENDED 30TH JUNE, 1890.

Dr.	£	s.	d.
To stock on hand, 1st July, 1889	25,985	18	2
,, Wages, purchases, etc.	73,719	2	1
,, Salaries, directors' fees, rent, office expenses, insurance, income tax, general and law charges	13,915	19	9
,, Depreciation on plant, etc.	1,838	17	9
,, Balance	61,115	3	3
	£176,575	1	0
Cr.	£	s.	d.
By sale of lamps, fittings, etc.	118,865	15	1
,, Interest, etc.	1,442	17	1
,, Stock on June 30th, 1890	56,266	8	10
	£176,575	1	0

BALANCE SHEET, 30TH JUNE, 1890.

Dr.	£	s.	d.	£	s.	d.
To share capital—						
5,000 A shares of £5 each, fully paid, allotted to the Edison Electric Light Company, Limited	25,000	0	0			
12,139 A shares of £5 each, fully paid, allotted to the Swan United Electric Light Company, Limited, ranking up to 5 per cent. for dividend on the amount credited as paid up, and afterwards, equally, per share, with A shares partly paid	60,695	0	0			
89,261 A shares, £5 each, £3 paid	267,783	0	0			
23,564 B shares, £5 each, fully paid	117,820	0	0			
				471,298	0	0
The B shares are entitled to one-fourth of the profits, after a cumulative preferential dividend of 7 per cent. per annum has been paid on the A shares. (The preferential cumulative dividend of 7 per cent. amounted, on 30th June, 1890, to £110,769. 17s.).						
,, Sundry credit balances				26,257	5	5
,, Reserve fund	£	s.	d.	4,595	10	10
,, Balance as per profit and loss acct.	61,115	3	3			
Less interim dividend at the rate of 7 per cent. per annum for six months ended 31st December, 1889, paid on 20th February, 1890	12,371	14	7			
				48,743	8	8
				£550,894	4	11
Cr.	£	s.	d.	£	s.	d.
By cost of patents, goodwill, preliminary outlay, loss on working, etc., as per last balance sheet	235,614	9	3			
Further expenditure thereon	2,439	5	1			
	238,053	14	4			
Less amount realised by sale of plant, etc.	2,030	15	6			
	236,022	18	10			
,, Amount of B shares of this Company, issued as *per contra*	117,820	0	0			
				353,842	18	10
,, Manchester Edison-Swan Co., Limited, £100,000 B shares at nominal cost				12,000	0	0
,, Freehold property				33,306	9	7
,, Plant and stock				77,221	2	11
,, Office furniture				256	17	2
,, Debtors				15,203	15	11
,, Investments				27,500	0	0
,, Cash at bankers and in hand				31,563	0	6
				£550,894	4	11

STATEMENT SHOWING THE PROPOSED APPROPRIATION OF PROFITS.

	£	s.	d.
To dividend for the year ending 30th June, 1890, at 7 per cent. per annum (of which £12,371. 14s. 7d. was paid as interim dividend on 20th February, 1890)	24,743	9	2
,, Payment of the balance of cumulative preferential dividend on the A shares, for the year ending 30th June, 1884, at the rate of 4 per cent.	14,139	2	4
And payment on account of cumulative preferential dividend on the A shares at the rate of 4 per cent. for the year ending 30th June, 1885	14,139	2	4
,, Reserve fund	8,093	9	5
	£61,115	3	3
	£	s.	d.
By balance of profit for current year to 30th June, 1890	61,115	3	3
	£61,115	3	3

NOTES.

Aberdeen.—The art gallery at Aberdeen in the Hammermen's Exhibition is to be lighted by electricity.

Electric Light at Bombay.—Four tenders for the electric lighting of part Bombay city are under consideration by the Municipal Standing Committee.

St. Pancras.—A report has been presented to the St. Pancras Vestry by a committee of that body, recommending the acceptance of tenders to the amount of £50,946, for supplying the electric light to that parish.

Magnetic Properties of Nickel.—We have received a copy of a paper on the "Magnetic Properties of Alloys of Nickel and Iron," by Dr. J. Hopkinson, F.R.S., reprinted from the *Proceedings* of the Royal Society.

American World's Fair.—The site for the grand exhibition of the World's Fair and Commemoration of the discovery of the New World, 1892, has been definitely chosen at Chicago, consisting of the conjoined lake-front and Jackson Park.

Growing Telegraph Poles.—It is stated that out in Nevada telegraph poles in low places, where water stands in winter, have taken root and are covered with foliage. The poles are cottonwood, and were planted with the bark on them.

Increasing Traction.—The Ries Electric Traction and Brake Company has been incorporated at Baltimore, U.S., for manufacturing the apparatus invented by E. E. Ries for increasing traction electrically. The capital stock is 2,000,000 dollars.

New Cable Between England and France.—A Reuter's telegram from Paris says the Budget Committee has approved the Bill authorising a credit for laying a new cable between England and France, and brought forward its report in the Chamber.

St. Catherine's Lighthouse.—It is stated that the light from the huge electric light in St. Catherine's Lighthouse, Isle of Wight, can be seen distinctly 45 miles away, and that at the Needles, 14 miles distant, it is quite easy to read very fine print by means of the light.

London County Council.—At the meeting of the London County Council on Tuesday it was resolved, upon the recommendation of the Parliamentary Committee, that the Electric Lighting Confirmation Bill should be opposed, so far as it did not comply with the Council's past resolutions.

Goole.—At the fortnightly meeting of the Goole Local Board, a letter was read from the Laing, Wharton, and Down Construction Syndicate inviting the inspection of their model electric station at the Royal Military Exhibition, and stating their willingness to supply any information on the subject.

Bishop Stortford.—A special meeting of the Bishop Stortford Local Board was recently held to consider the application of the new company for a provisional order, and Mr. J. A. Findley, the secretary, gave some information as to the proposals and the power over breaking up of roads. The matter was adjourned.

Barnet.—At the last meeting of the Barnet Local Board, a letter was read from Mr. Joel giving notice that the Barnet District Electric Light Supply Company were about to apply for powers to supply the electric light in the district of the East Barnet Valley Local Board. This was referred to the Highways Committee.

Concentric Wiring.—We have received the catalogue of fittings from Messrs. J. D. F. Andrews and Co. These fittings are all on the concentric wire system, the advantages of which are claimed as, "cheaper first cost, no wood casing, self-testing, every fault resolves itself into a short circuit and melts the fuse." The catalogue contains illustrations of switches and fuses for this system which has been developed, it is stated, during many years in its application to over 60 installations, and is said to be specially applicable to ship lighting.

Gravesend Fete.—A grand summer fête was held in aid of the Gravesend Hospital last Tuesday, and was opened by Lord and Countess Darnley. The authorities of Tilbury Docks were specially liberal in respect to the electric lighting of the fête, which was carried out under the supervision of Mr. Stanley Bright, electrical engineer to the London and India Dock Company, assisted by the electric light staff of Tilbury. The motive power was supplied by an engine lent by Messrs. Wyle's Agricultural Implement Co., Limited, of Rochester, an 8 h.p., running at 200 revolutions per minute. The dynamo and lamps were kindly lent by the London and India Docks Joint Committee. The lighting consisted of three of Crompton's patent arc lamps of 5,000 c.p. each, the operation of which gave great satisfaction. The fête seems to have been both in the daytime, and in the night-time (due to the electric light), an "unparalleled success.'

The British Association.—A meeting of the Leeds Executive Committee was held on Monday for the purpose of considering arrangements which has been made there in view of the approaching visit of the British Association to that town. The Mayor, Alderman Elmsley, in opening the proceedings, said the executive committee had received promises to come from some of the most eminent scientists in Europe and America. Many of the principal manufacturers of Leeds had most generously consented to open their works for inspection by members of the association. They had also arranged for excursions to places of interest, historical or otherwise. He had no doubt that the inhabitants of Leeds would show all the hospitality and enthusiasm that was required. In the course of the proceedings it was stated that it was the original intention to have a guarantee fund of not less than £500, and that fund now amounted to not less than £6,540.

Tempered Copper.—The tempered copper manufactured by the Eureka Tempered Copper Company, of North East, Pennsylvania, says the New York *Electrical Review*, has passed beyond the experimental stage as regards its use for commutators and electrical brushes. It has been tried by all the large manufacturers of electric light and power dynamos, and by at least one half of the central stations of the United States, under a positive guarantee of three times the wear of copper or bronze, whether castings or drop forgings. In the face of this large trade, under this guarantee, in no instance, we are informed, has any goods ever furnished for electrical work by this firm been returned or payment refused. For street car work it is especially adapted for gear pinions, as well as commutator segments and trolley wheels or trolley wire. They also make a gear pinion of alternate sections of copper and raw hide that has been used successfully upon several electrical railroads.

Ward's Electric Omnibus.—The electrical omnibus is a fact in London. On Tuesday at three in the afternoon we met, quite in the ordinary course of affairs, coming down

St. Martin's-lane, into Trafalgar-square, the first of the new line of electrical omnibuses, glorious in its new varnish and gold letters, driven in person by Mr. Radcliffe Ward, the managing director. The omnibus came down the street with two passengers outside and one inside and a conductor, at a rattling pace, followed, as was but natural, by a crowd of street boys. It looks a trifle heavy and short, but altogether has quite a handsome appearance, and the pace it made and the way it could be steered in and out of the carts and cabs showed it was well under control. "Well, that's a rum 'un," said the driver of the yellow bus at the corner; "We'll all have to turn 'lectric men, next, it seems." Some of them will no doubt; and omnibus companies in all the great capitals will watch with interest this new line of omnibuses.

Sims-Edison Torpedo.—An exhibition was given by the Sims-Edison Electric Torpedo Company of their fish torpedo at Willet's Point on July 15. The torpedo is in two parts, one parallel to and about 6ft. above the other, and 28ft. long. The lower portion is a cylinder with conical ends covered with copper, containing the explosive used, the controlling cable about ½in. in diameter made of fine, twisted copper wire, which is paid out as the torpedo advances, and the electric motor and steering gear. The upper part consisted of a float of copper. In the tests, says the N.Y. *Engineering News*, one mile of cable was laid in 2min. 59sec. The float was at no time exposed more than an inch above the water. The exhibition showed the perfect control of the torpedo by the operator on shore. The torpedo was run a half mile down the bay, turned and zigzagged in various directions, and finally brought back to the starting point. The current used was of 1,000 volts pressure. The company is now building a 33ft. torpedo for the United States Government.

Electricity from Heat.—The news of a discovery by H. B. Cox, of Hartford, of a method of generating electricity direct from heat proves to be a little in anticipation of the facts of the case, as, indeed, we quite expected it to be. We gave a week or two ago the report of the invention from the Hartford paper, and at the same time communicated with Mr. F. A. Pratt, of the Pratt and Whitney Company, Hartford, who, it was mentioned, was president of the company formed to develop the heat electrical generator. He writes that the invention is not perfected yet, and, possibly, may never be, as inventions of this kind are proverbially uncertain. They hope to know more and report progress before the end of the year; but the hopes of the solution of the problem have not as good foundation as the article laid down, or as might for the progress of science be wished. So we must wait. The problem is there, is continually before us, and probably the solution, if we but knew it, is not in reality very far to seek; and engineers, feeling this, are ready to give all attention to an inventor who shall indicate to them the right road.

Testing Apparatus for Leamington.—At a meeting of the Leamington Town Council last week, after the reading of the report of the Watch Committee, Mr. Crowther Davies again returned to the charge and said that, unlike the gas, the electric lighting was eminently unsatisfactory, and the ratepayers were dissatisfied at the light they received. He suggested that in future reports a statement should be included as to the condition of the light, whether the committee were satisfied, and whether the electric lighting for the previous month had been in accordance with the terms of the contract. Mr. Davies said that he hoped there was no probability of the Council ever occupying the position of the company now supplying the electric light by acquiring the plant, etc. The Mayor said he was certain it was not in the mind of any member of the Corporation to take over the plant of the electric lighting company. The surveyor was instructed to purchase an instrument for the purpose of testing the electric light, and it was agreed that the particulars named by Mr. Crowther Davies should be included in future reports.

Mining Exhibition.—The exhibition of mining and metallurgy was opened at the Crystal Palace on Monday. There is every reason to believe that this exhibition will prove interesting and profitable to mining engineers, but from the point of view of electrical engineers there is not a great deal to be said. The exhibition is lighted, and well lighted, by the Planet arc lamps, but beyond bells, indicators, a few fittings, and electric mining fuses, there does not seem to be much to indicate the change that will inevitably take place, especially in mountain districts where water power is available, in the substitution of electric for steam power. The chance was here to demonstrate to the mining and colonial world the advantages of the transmission of power, of the electric hauling and pumping engines, and electric drills, besides underground electric lighting, but we do not see that the opportunity has been greatly appreciated. The exhibition is of mining and mining machinery, and of this there is plenty, and fine exhibits come from New South Wales. We notice still a good many blank places in the catalogue; possibly some of these will show forth the application of electricity to mining.

Closed or Slotted Conduits.—A note for electric tramway engineers that they will do well to ponder over. Some two years ago Mr. Lineff laid down and tried an electrical system in which the essential feature was an open slot in one of the rails. Though fairly successful in working, the presence of the open slot in the roadway was considered so objectionable by the local authorities that they refused to sanction the working of the system, and it has never been put in actual practice. Gradually the necessities of the case are evolving the final English electrical tramway system. Overhead wires are not allowed—they are unsightly, dangerous, troublesome; open slots are not allowed—they are dangerous to cart-wheels, an open receptacle for dirt, besides being costly to put down. The race seems to lie between accumulator cars and the closed conduit system. The race, too, is becoming exciting. We are in confidence of several schemes which have not yet come before the public, even technical public, notice. Money is being invested, and brains are being vigorously taxed, and soon we hope to see a practical outcome in the rapid extension of finished, economical, safe, and simple means of electrical traction in our streets.

Accumulators in Telegraphy.—Herr Strecker, engineer-in-chief of the telegraphic service at Berlin, has recently read a paper before the Elektrotechnischen Verein upon the mode of employment of accumulators in the central telegraph office of the city. The following interesting particulars are given: In October last the administration put in 25 batteries of Tudor storage cells, of 25 ampere-hours; the current is distributed in three directions and serves 68 lines, comprising 41 Morse instruments and 27 Hughes instruments. The three principal cables, in parallel from the battery, supply the first 36 lines at 34 volts, the second 12 lines at 40 volts, and the third 13 lines at 50 volts, six at 60 volts, and one at 80 volts. Shortly four other main circuits will be connected. The negative pole of the battery is put to earth, and the strength of the

current is regulated so that it shall not exceed the strength of 60 milliamperes. The capacity of the battery equals one month's service; nevertheless the battery is charged up every 10 days by means of a shunt-wound Siemens dynamo, driven by a 5 h.p. gas motor, the charging current being seven amperes. The telegraph authorities of Berlin intend to increase the service by means of accumulators.

Ferranti System in France.—A fresh issue of capital, under the auspices of the Banque Commerciale et Industrielle, has been made by the Compagnie Nationale de l'Electricité for the extended exploitation of Ferranti dynamos in France, of which it has the monopoly, and which have been adopted in competition by the Municipality of Paris. The company claim the following advantages: transmission to a long distance with but slight loss of energy (3 per cent. for eight miles), economy of 80 per cent. in the distributing mains, due to the absence of large cables or special conduits, by the use of small wires placed in the ground; power of the dynamos, each capable of feeding 500 to 30,000 lamps, thus giving economy in supervision, space, and maintenance; easy installation in cheap sites at considerable distance from district of supply; economy of cost and consequent ability of cheaper supply. The company already has supplied dynamos to Nancy, Havre, Troyes, and several other towns in France, and it is in treaty with Nantes, Calais, Dijon, Clermont-Ferrand, Versailles, Caen, Angers, Reims, Epernay, and other towns. It is to provide for the rapid satisfaction of these towns, and to spread the circle of its operations, that the new issue of capital has been made.

Electric Welding and Ice Machines.—The ice famine is proving a bonanza for the Thomson Electric Welding Company, says the *Boston Advertiser*. There is a great demand at present for pipe welding machines, with which to make the long coils of pipe for artificial ice machines, for brewery coils, for sugar refinery, and general refrigerating purposes. The pipes originally come in lengths of from 18ft. to 20ft. The coils are frequently 600ft. to 700ft. long. By old systems the pipe is welded together by a slow and laborious process, requiring 15 minutes for each weld, two blacksmiths, and a dozen helpers, and a large space, each pipe being lifted from the forge to the anvil and a mandril inserted. There is often a serious loss of ammonia as a consequence of imperfect welding. By the electric process the welds can be made so homogeneous that there is no chance for ammonia to escape. The length of time required is two minutes for each weld, and all the help required is a man and a boy. The cost of the old process is 15 cents each; by the new, two cents. As the coil is bent after each weld, the work can be done in a very small space. The managers of the welding company considered this, next to shell welding, the most important industry which has sprung up as a result of the welding invention.

Goulding's Adjustable Telephone Transmitter. A simple improvement in the telephone, or rather its mounting, has been designed by Mr. J. Cuthbert Goulding, of Cardiff, to remove an inconvenience common to the present form of telephone. This is to enable the whole telephonic apparatus to be readily adapted to anyone's stature, and to any position the user may be in, either sitting, standing, or even lying down. The wires are given considerable play, and the telephone is placed upon a carriage, which slides easily up and down hollow brass rails. Inside these rails are balances of the approximate weight of the telephone and its carriage. The balances are suspended by cords, which pass over pulleys and are fastened to the carriage. A handle, which also acts as a stop and clamps the telephone firmly against the rails at any required height, is placed in the middle of the carriage. Several eminent telephone engineers have inspected this device, and have pronounced most favourably upon it. It is considered, besides the advantage of adaptability, that it will obviate all vibration which generally arises from contact with the wall, and which is too often vexatious to the user of the telephone. Woodhouse and Rawson United, Limited, are making these instruments, and we hear that they are rapidly coming into favour.

A Discovery.—Prof. R. H. Thurston is credited with the discovery of the means by which a large, possibly a very large, increase of efficiency might be made in steam engines. At the Cresson Convention of the American Society of Civil Engineers Prof. Thurston read a paper upon "A Practical Method for Reducing the Internal Wastes of the Steam Engine." This method (Patent 382,972) consists in coating the unfinished interior parts of the cylinder—those not rubbed by the piston—with a graphitic non-conducting coating, thus avoiding internal condensation. The parts are subjected to a bath of dilute sulphuric acid for 48 hours, and then the surfaces are oiled and left to dry for 24 hours. The saving of heat transmitted through the cylinder head and other parts, according to certain tests of 40 minutes duration he has published, is 40 per cent. The professor estimates, with what justice remains to be seen (and there seems a certain amount of doubt in the subject), "that this simple process should reduce the cylinder waste by at least one-half, which in ordinary practice means from 10 to 20 per cent. of all steam used." Such an improvement by simple means, applicable to all steam engines and not involving any constructive changes, would mean a vast and important improvement—almost a revolution—in steam engine practice; and it is to be hoped that further researches will show at least some solid basis for Prof. Thurston's claims.

Electricity on Board Ship.—"The two-wire system," says Gilbert Wilkes, U.S. Navy, in a recent paper before the American electrical engineers, "has always been used in the American naval service; the ship is never allowed to form the return circuit. On account of the present beginning of motor work on board ship, and the future developments confidently looked for, the direct current has always been used." But he then goes on to say, with reference to electric welding (and we know these are usually alternate-current machines)—"One electrical application that presents many advantages on board a man-of-war, especially when on a foreign station, is electrical welding. When, however, it is introduced on ship board, the pressure of the generator should be reduced to 80 volts, in order that in case of emergency it might be used for lighting purposes, and the welders should have several sets of adjustable clamps. Welding machines have not yet been actually used on ship board, but it is to be hoped that their introduction is a development of the near future. They cannot supplant any of the existing dynamos, owing to the necessity of motors, but must come in to occupy a place of their own, to almost entirely supplant the ship's forge and add to the general useful equipment. Thus an ideal ship plant will include arc lamps, incandescent lamps, constant-potential motors, a welding generator, and welders. Small motors," he adds, "for drilling purposes have, in the New York Navy Yard, almost completely driven out the portable steam engine, countershaft, and belt."

Electric Light in War.—Sir Evelyn Wood, in his report on the night operations carried out recently in order to test the value of the electric light, says: "Church Plateau redoubt was occupied by a company of infantry and half a battery of artillery. The Lieutenant-General and Commanding Royal Engineers, who had charge of the working of the light and the defence of the redoubt, stood near its front face, the observing station being at a little distance. When the signal-rocket went up to indicate the commencement of operations, three infantry brigades moved by different routes towards the Queen's Parade. The search-light was not attempted at greater distances than 1,100, 1,200, and 1,400 yards. The march of the third brigade, sent purposely across the right front of the redoubt, was not discovered by those in the redoubt, although seen from the observing station. The first brigade was never seen until close to the redoubt immediately before the "cease fire" sounded, although the light was passed over it several times. There was considerable difficulty in controlling the action of the light. It was dazzling for those advancing under its gleams, but when regarded through field-glasses gave no inconvenience. It also enabled a fine sight to be taken on rifles at the heads of gunners in the redoubt, who were not, however, seen by the other brigades. The glitter of sword scabbards and red coats rendering discovery easy, indicates that capes should be worn at all night operations by attackers, and scabbards should be dulled."

Solid Accumulators.—The great field which is opening for the use of storage cells in tramcars, omnibuses, and hauling locomotives is resulting in a determined search for a solidly built accumulator, which shall stand a considerable amount of knocking about, both from vibration arising from irregularities of the way and from shocks due to running against cars or stopblocks, and from the shock of sudden breaking of the cars. Mr. Reckenzaun has very successfully attacked the problem from the point of view of solidity of plates. He has devised a method of manufacture which has in practice proved a valuable one for treating accumulators, and sets of these, in the colonies and America, have done most excellent work, lasting for years. Mr. Barber-Starkey and M. Schoop have each, in their way, attacked the subject from the point of view of solidity of the cell itself. Mr. Barber-Starkey fills in the space between the plates with plaster of Paris, and experiments at Barking have tended to prove that this may be a practical advance in traction science, but the disadvantage is present of increase in internal resistance. The Schoop accumulator, made by the Oerlikon Company, of Zurich, also has the space between the plates filled in solid. The composition in this case is formed of a gelatinous silica, obtained by precipitating a solution of silicate of soda, density 1·18, by sulphuric acid of density 1·25—three volumes of acid to one of silicate. During the period of charge the upper face of the mass of silica is covered with a layer of acidulated water, which disappears during discharge, to again reappear on charging. In this accumulator also the disadvantage appears to be the increase of internal resistance, and the capacity is only three-quarters that which it would be if the electrolyte were liquid; but the possible rate of discharge seems to be considerably higher than with ordinary cells, and the battery is not damaged by a short-circuit. The work of practical investigators in these fields seems to promise good results, and it will be the business of traction engineers to encourage, test, and put to practice these forms, and others when they are presented, of so-called solid storage cells. The field before them is a large one, and if the attendant disadvantages can be greatly overcome, the solid accumulator may prove a touchstone of fortune to both makers and users.

Elmore's Copper.—The shareholders in the copper-depositing company came in for a boom on Monday last, when the first annual meeting took place and a dividend of 25 per cent. was declared. This, it is hardly necessary to say, is not a dividend for manufacturing—not yet, though this is also anticipated. The present profit consists principally in £107,111 from the sale of the patent to manufacture wire. After writing out or "placing to the reserve" £20,000 for the original estimate of this patent, distributing £35,000 to the shareholders, there was a balance from profit and loss of £40,000. The delay in manufacturing was explained as owing to the change of site of works from Sheffield to Leeds, where there is a canal—incidentally, the canal owners have built a wharf for them under cost price—and land for extension. The wire process has been so developed and proved as to gain the confidence of the trade, and the whole possible output is contracted for some time to come to wire mills in Birmingham. The same conciliatory attitude is to be taken with other departments. They have started a first five-ton-a-week plant to gain experience, not only as to manufacture, but as to requirements in the trade. £8,000 have been spent in buildings, with a siding 500 yards long, and the wharf. Unfortunately, the engine, by one of the best makers, broke down and a new engine had to be substituted. On the other hand, on the stock of copper, the price having gone up, there is a profit of £1,000. The cost of manufacture also is found considerably less than estimated. They have received a large number of orders, more even than the capacity of their extended works, and have not been able to take them all. Mr. Elmore believed that in six months they would be able to pay a dividend from manufacturing. They were actually earning money at the present moment from manufacturing. An amendment was moved at the meeting to carry £30,000 to a reserve fund and distribute the balance, but the shareholders preferred the cash, and the 25 per cent. will be distributed this week.

Westinghouse System for Barnsley.—The tender of the Westinghouse Company for a central station for Barnsley for the sum of £17,800 has been adopted. A meeting of the Barnsley Town Council was held on Tuesday at the Town Hall, the Mayor in the chair. A further discussion took place on the recommendations of the Lighting Committee that the tender of the Westinghouse Electric Company, for the construction of an electric lighting plant to light the inner area of the town with the electric light, such estimate amounting to £17,800, with other expenses making it £18,500, be accepted. Mr. Raley resumed the debate adjourned from last meeting, urging that for cleanliness, healthfulness, and purity the electric light was preferable to gas, and because the people wanted it they ought to have it, and he contended that in the course of a short time it would pay. Alderman Tyas submitted that the recommendation was premature, and moved that the tender of the Westinghouse Company be not accepted, but that the question be referred back for further consideration. The scheme was incomplete, did not get rid of a monopoly, would increase the cost, and by-and-by they should have some improvement. Alderman Marsden seconded the amendment, and in doing so submitted that the estimates which had been made were not reliable, and instancing the case of gas where Mr. Hawkes

ley had informed the gas company that they could put down a plant for from £4,000 to £9,000, but it had cost five times that amount. He suggested that an attempt should be made to purchase the gas works, and said that the gas company would meet them courteously if they made such proposals. He would not give any price that was asked, but would appoint valuers, with an umpire, to decide the price, and if necessary would take compulsory powers. He urged that the electric light, where it had been used, had not been successful, mentioning Barnet, Leamington, and Taunton, the cost being much greater than that of gas. Mr. E. Bailey pointed out that this was no estimate, but an actual tender, and private companies were making a profit by supplying the electric light where gas was 1s. 10d. per thousand, whilst here gas was 3s. 4d. per thousand. He showed by a calculation of his own payments for gas that the cost would be little, if any, more per light per annum for the electric light than was paid for gas in Barnsley at 3s. 4d. per thousand. Other speakers followed on the same side, and the recommendation of the committee was finally adopted, after a four hours' debate, by 15 to five.

Electrolysis of Tumours.—Dr. Abrath, of Sunderland, has for some years been experimenting with instruments for the electrolysis of diseased parts of the human body. In a recent letter in the *Hospital Gazette* Dr. Abrath states, with regard to tumours, cancerous or otherwise, that he has removed these with ease by electricity where no surgical interference with the knife was possible—cases which have baffled all medical and surgical treatment, including liniments or injections. More than a dozen cases of large tumours of the head, neck, and throat he has first had photographed in their diseased state. Grown-up people who had been under hospital treatment and dismissed incurable, have escaped the horrors of suffocation or other miserable death. These he has also had photographed in their perfectly cured state after electric treatment. Further, he has a case of a large scirrhus cancer in front of and above the ear, invading the external ear, and extending deep downwards into the neck—a most remarkable one, the patient being a sea-faring man, aged 69, and whose mother died of cancer of the breast at the age of 75. This growth he removed by electrolysis, and the man is now going to sea again. This it would have been impossible to remove with the knife. The doctor mentions cases of deafness, and gives a long list of diseases which he maintains can be successfully treated by electricity. Dr. Abrath states many good results that have followed his operations on cancerous breasts with the knife, but he advocates the use of electricity in preference to the knife. The latter only removes the cancer as far as the knife goes, while the electric current will kill the cancer cells beyond where the knife can go. He further asserts that it is an established fact that hæmorrhage and shock are more or less prevented with the use of electrolysis, and *scepticæmia* or *pyæmia*, which often follows removal with the knife, is nearly always avoided. "At the same time," he says, "let no one think that I hold up electricity as a panacea for the cure of all ailments to which the human frame is liable. In many cases we may try its application in vain, but taking it on the whole, and the practical results emanating from the use of the remedy, it puts in many instances all other therapeutical agents in medicine, surgery, midwifery, and gynæcology into the shade, and it cannot be too often repeated that in the hands of a scientific and practical electrician it is a very safe remedy." The subject is not exactly in our line—it is more a medical than an electrical problem; but as an illustration of the application of electric science to surgery the treatment of diseased parts by electrolysis cannot fail to be generally interesting, and in the future possibly widely adopted in the medical profession.

Saunderson's Hydro-Carbon Arc Light.—A public display of arc light, in which Saunderson's cored and vaselined carbons are burnt, has now been made at Waterloo Station for some six weeks—since May 27 until last Saturday—and, as we noticed last week, the results have proved highly satisfactory. On Thursday evening, 24th inst., we went to Waterloo to examine the new light in actual work. One of the arc lamps inside the new station was burning with the new carbons, and two others near it with the ordinary carbons. The whole of the lamps were worked in series, each lamp consuming the same energy, or so nearly that the difference must be quite fractional. We found the light exceedingly white, slightly more inclining to yellow than the other lamps, and the apparent focus both looked more brilliant and larger and the general illumination of the globe more brilliant than either of the other two—certainly having the appearance of a far stronger lamp. This was the first effect to the eye. We then made some rough but practical tests upon the strength of light. It would, of course, be quite impracticable without special apparatus to take a photometric test in a place like Waterloo Station to compare with the exhaustive experiments and results by Dr. Hopkinson, which have already been given. In these it will be remembered that taking the best light obtainable with ordinary carbons as unity, the new light was found to be 1·88, or nearly double, using rather less energy; and calculating the amount of light due to the difference in energy, the light from the new carbons was rather more than double that from the best ordinary carbons obtainable. Our tests in the station consisted in pacing the distance between two lamps until the shadows were equal, or again till the light on the two sides of white paper was appreciably the same. It must be mentioned that the new lamp was by itself, to one side, so that the light from other lamps could not help it, but rather the reverse. The light was appreciably equal at 13 paces from the new and nine paces from the ordinary lamp, again at 15 and 11 paces, a result which, taking the square of the distances, indicates the strength of the light to be practically double that of either of the other two. Several tests were taken with different lamps and at different times during the evening, and although the tests were, as we have said, necessarily approximate, yet the general average should come somewhere near the truth. One series showed an average of 1·9, and with another lamp 2·1, certainly confirming, for practical purposes, Dr. Hopkinson's report that the new light may be taken to be double that of the old for the same energy expended. We trust those who have to do with arc lighting will also test the new carbon and publish the result. We think there should be a great future before this invention, and heartily wish the inventor the success it deserves. It is not intended to disturb any of the lamp interests now established, as the new carbon can be adopted for any lamp equally with the old carbons. It will not be found necessary to make any alteration of the lamp, or if in some special patterns a modification should be required it would be of the simplest and most inexpensive kind for the carbon holders. Large carbons are being prepared for the heavy projectors, and great interest is being taken in the matter by the lighthouse authorities, but it is to the ordinary commercial type to which we refer in this notice.

THE ETHER THEORY OF ELECTRICITY.

AN INTERVIEW WITH MR. J. JOHNSTONE.

At the meeting of the Institution of Electrical Engineers at Edinburgh, notice was given by the secretary that a letter had been received from Mr. J. Johnstone, of Merchiston-park, Edinburgh, the author of a recent work upon the "Ether Theory of Electricity," inviting any of the members to his laboratory at 8, Dalhousie-terrace, to inspect the apparatus and witness the experiments described in his book bearing upon the theory of electricity. As the time of visitors was limited and there was much to be seen at the exhibition, it seemed very probable that none of the members would be able to avail themselves of this offer, and our representative therefore made a special effort to call upon Mr. Johnstone so as to be able to give our readers some idea of the said experiments and the theories put forward. There seems to be a floating idea that Mr. Johnstone, whose book was recently mentioned by Prof. Oliver Lodge, has done some special work and promulgated some special theories, but exactly what these were did not seem to be clear. It was, therefore, with some interest that we called upon Mr. Johnstone. Mr. Johnstone is now an old man—his earliest experiments date from 1839—white-haired, and though, with the necessity of using a strong magnifying glass in reading, is most earnest and enthusiastic in his work and experiments. He dwells in one of the large commodious stone-built houses on the brow of the hill overlooking the exhibition, and although the hour was yet early for London people, he was preparing to retire, to rise at four the next morning and prosecute his experiments. His house is in Merchiston-park, quite close to the classic site where dwelt Napier of Merchiston, the inventor of logarithms.

Briefly, the matter Mr. Johnstone has in hand is this: It is purely a question of scientific interest, of electrical theory, and priority of discovery of facts which will or may lead to important results in teaching and possibly in practice. He is in entire antagonism, in the first place, to Faraday's conception that in the Leyden jar the glass molecules are in a state of tension between two electricities. He is of opinion that a direct discharge or *current* takes place actually through the glass until such time as the potential of charge rises too high, when the flow is by some means suddenly choked, and the electricity accumulates potential, whereupon the Leyden jar is charged, and a spark or air discharge between the inner and outer coating can take place. From this standpoint of what occurs, based upon experiments to be mentioned, Mr. Johnstone argues electricity to be a single entity or substance, and neither a force, nor two electricities, or two states of that electricity.

The experiments are as follows: In the first place, the whole series depends upon the discovery made by Mr. Johnstone, in 1839, that an insulated gas flame affords the best test of the direction of static electrical currents. A chemist's dropping-tube is attached first to a gas tap, and then by a flexible tube to the main; the flame upon this being thus insulated is found to be directed or blown to one side or the other on interposing it between points on a static circuit, and becomes an invaluable and infallible test for direction of current; the tendency of the electrified molecules of the air being no doubt the cause of this. Continued tests having finally determined the insulated flame as a constant indicator of current direction, the flame was interposed in the ground circuit or negative side of a friction machine. Instead of a negative current flowing from the machine, the flame shows a positive current towards the machine, a sufficiently interesting experiment. The direction can thus be easily tested of the Holtz or Wimshurst machines.

Now for the Leyden jar. The jar is laid on its side, with the inside coating connected to one pole of the machine; the outside coating has a pointed wire attached to it and facing another point put to earth. If now the machine be gently turned, the jar is electrified. In ordinary acceptation the positive charge accumulates, while the excess negative charge disappears to earth. What happens, however, tested by the flame, is that a steady current passes, apparently (and so considered by Mr. Johnstone as correct in theory) directly through the molecules of the glass. This current can be maintained hour by hour, day by day, or week by week, passing constantly through the glass, if the potential be not raised too high. On working the machine at a higher potential, however, a change appears. The current as shown by the test flame suddenly ceases; the electricity seems theoretically, by excess of potential, to choke in the pores of the glass and none can pass. The charge accumulates and the jar is charged, and a spark passes. But, maintains Mr. Johnstone, not through a state of strain of the molecules between two electricities, but by some inherent change in the attraction of cohesion of its particles, the frictional machine all along acting merely as a pump for one kind of electricity; and this electricity, says Mr. Johnstone, an ethereal substance, and not a state of motion.

This change of the attraction of cohesion by electrical effect Mr. Johnstone most strikingly shows in a further experiment. Two sheets of patent glass, size 13in. by 10in., are both coated, one upon the upper and the other on the lower surface, with a square decimetre of tinfoil in the centre of each. The two glass surfaces are then rubbed together, when, with the natural cohesion of smooth surfaces, they stick somewhat together. This attraction of the upper upon the lower can be measured by weighing in a balance first the actual weight of the glass only, and then with the natural cohesion. The excess weight with cohesion is found to be some two or three grains. Now, if the two surfaces of tinfoil be electrified, the following astonishing result is obtained: the attraction—or the electrical cohesion—is found to have risen to the amount of 1,650 grains; German plate, British plate, and other makes yield figures varying from 1,100 down to 400 grains. Recent experiments seem to show that successive charges show a diminution in electrical cohesion on second and third charges in the ratio of 1,020, 1,000, and 800 grains—a point which will bear further investigation.

Experiments have also been made with the thinnest Florence flasks up to thick glass, tested by the flame, all tending to show that a steady current can be made to pass directly through glass. Mr. Johnstone has shown his experiments recently before the professors and students at one of the colleges in Glasgow, greatly to their interest. He considers that the experiments published by him have demonstrated facts hitherto not acknowledged, and that the teaching of theoretical statical electrical science in the schools should be modified in accordance with these facts.

SOME CHIEF FEATURES, MAINLY ELECTRICAL, OF THE EDINBURGH INTERNATIONAL EXHIBITION, 1890.*

BY DR. WALMSLEY.

(*Concluded from page 81.*)

Considering the position of the exhibition, it is but natural that most of the exhibitors of dynamos and engines should include a set of ship lighting plant amongst their other exhibits. For the convenience of those visitors who are interested in this branch of electrical work, I have embodied in Table A a few particulars of the different combinations that are open to their inspection. In the last column I have calculated as being of some interest the number of watts available in the outer current per square foot of floor space occupied. Of course, I do not mean to imply that this is the only or even the most important thing to be considered in selecting ship lighting plant, but it is interesting as showing what can be done in this direction. In comparing these numbers the steam pressures given in another column must not be overlooked.

The only purely American lighting exhibit is a 30 arc light dynamo, together with 30 arc lamps, of the Western Electric Company, of Chicago. The dynamo is regulated for constant current by a complicated mechanism, which alters the lead. Some of our visitors will, I think, be interested if they will compare various details connected with this machine with English-built machines. The switch that is to open a 900-volt circuit is worth more than a passing glance. The lamp is a well-made and simple clutch lamp. Perhaps the only special point about its mechanism is the very small amount of travel and the strong pull required on the armature of the series magnet to strike the arc. It is to be fed with a

*Paper read before the meeting of the Institution of Electrical Engineers at Edinburgh, July 16, 1890.

system. The time taken to make the round trip is 3·8 minutes, so that the average speed attained is about four miles per hour.

The power required is supplied from a Statter dynamo in the Machinery Hall, on the stand of the Electrical Engineering Corporation, who have constructed the line. This dynamo is of the well-known single-magnet type, is compound-wound, and capable of giving 240 amperes at 110 volts, so that there is an ample margin between its possible output and the power required. No tests have yet been made of the economy of the system.

The power for the electric railway is generated by two Stockport gas-engines, each of 16 nominal horse-power. These drive, from a countershaft, two Statter shunt-wound dynamos connected in series and each capable of giving 90 amperes at 150 volts. The current is conveyed to the cars, of which there are two, by means of trailing contacts running along a light overhead phosphor bronze wire of No. 1 S.W.G.; the return is through the rails, where the fishplates are backed with lead to give continuity. The current passes to a switch and through an adjustable wire gauze resistance underneath the car to a shunt-wound Statter motor of the single-magnet type. The brushes are end on to the commutator, and the motion is reversed by reversing the current in the field-magnets by means of a second switch. As the motor at full speed runs at 1,200 revolutions it is geared down to the driving wheels by two steps of helical gearing. The track is three-quarters mile long, has two sharp curves, and at one place has a gradient of 1 in 50. The cars are ordinary light tramcars, carrying 28 passengers. It would, therefore, appear desirable to make some exact experiments on the efficiency of the working. I should mention that the electrical part of the railway has been carried out by the Electrical Engineering Corporation. The same company also exhibits three constant-current motors with centrifugal governors, which are to be driven from a constant-current dynamo which is regulated to give a current of 55 amperes with an E.M.F. up to 750 volts.

In various parts of the exhibition there are quite a number of exhibits requiring a small amount of power which are driven by electric motors, a fact which shows that the electric transmission of power is becoming better known and appreciated by small users.

The Electric Construction Corporation exhibit an accumulator tramcar, which shows the method of rapidly changing the cells. These are 96 in number in 12 blocks of eight each, each block automatically making contact with the car conductors as it is slipped into its place. Specimens of the cells used are exhibited, and a motor bogie completely fitted is shown separate from the car. The motor has block brushes and is geared down with helical gearing. The same corporation shows specimens of special boat cells and small cells for railway lighting, and has recently put on its stand a Sprague motor with the gearing usually employed in America for tramway traction under the Sprague system.

In the French Court an example of the electric transmission of power is exhibited in the shape of an electric capstan, which is now used throughout the system of the Northern Railway of France. The Hillairet motor employed is driven from accumulators of the Laurent-Cèly type. Another Hillairet motor is shown fixed between the rails of a railway for the purpose of moving over the points. Two solid drums are keyed to the ends of the motor shaft, each bearing on its surface a single complete turn of a spiral groove of large pitch. The points are moved by pins running in these grooves, and a single turn of the motor armature is sufficient to throw the points over, the current being broken as soon as they are put over. In these circumstances it is difficult to grasp the special advantage of employing a relatively costly electric motor to give this turn. The system is, however, being practically tried on the Northern Railway under M. Sartsoux, the engineer.

Measuring Instruments.

Although several well-known makers of measuring instruments are not directly exhibiting, they are indirectly represented by their instruments being in actual use in various parts of the exhibition.

There are, however, several good exhibits of electrical instruments as such. The first place undoubtedly belongs to the case in which Mr. James White exhibits Sir William Thomson's latest forms of current and voltmeters. These have been already so well described to the Institution that it is quite unnecessary for me to enter into details. Amongst the balances, however, one may notice a composite balance, which was not, if I remember rightly, shown when Sir William Thomson read his paper before the Institution. This balance will either measure currents from ·02 to 300 amperes, or power from 100 to 25,000 watts at 100 volts.

A very complete set of Prof. James Blyth's ingenious measuring instruments is also shown. These have been fully described in the columns of the technical journals as they have been brought out from time to time during the last seven or eight years, but as many of my hearers have probably not seen the actual instruments I think it would be well for them to take this opportunity of inspecting them.

Messrs. Latimer Clark, Muirhead, and Co., Messrs. Paterson and Cooper, and Messrs. Woodhouse and Rawson exhibit their various well-known types of instruments.

In the French section Messrs. Richard Frères show several interesting forms of registering ampere-meters and voltmeters, and an engine-room ampere-meter with a corresponding voltmeter having dials 14in. in diameter. The well-known Deprez and Carpentier instruments are also exhibited.

In the same section there are to be seen several specimens of the Cauderay and Cauderay-Fraser joulemeters. In the latter of these ingenious instruments the series coil is fixed and the shunt coil pivoted. The latter carries a long pointer, which takes up a definite position for a definite amount of power used. The end of this pointer rests on a flat cam, which is turned once round by the counting mechanism in a definite time, depending on the volts used, the position of the pointer determining during what fraction of this time it shall rest upon the plate. The counter mechanism is such that the finger on the dial only moves forward whilst the pointer rests on the plate, and thus the watts are integrated. With an instrument like this it is, of course, necessary that the power to be integrated should not be subjected to continual rapid fluctuations.

Messrs. Schuckert and Co. exhibit a series of their well-known ampere-meters and voltmeters, measuring up to 1,000 amperes and 1,000 volts respectively.

Telephones, etc.

The telephone exhibits do not offer many striking novelties for comment. The exhibit of the Consolidated Telephone Construction Company is close to the entrance of the French Court, in which there are displays of the telephone productions of the French General Telephone Company, and of several private firms. The visitor can therefore, within a small compass, compare the instruments produced under the close monopoly which prevails in this country with those which are the outcome of the competition between these various French firms.

An ingenious automatic switchboard with transmitter, receiver, etc., is shown by the Consolidated Company. It should be of great service to hotels, works, warehouses, etc., which require the use of several telephones without the expense of an exchange installation. The user of any board can ring up and converse with whoever is at any one of the other boards, and the mere act of hanging up his receiver when he has finished with it clears the line.

The National Telephone Company also display a few exhibits, amongst which is a Bennett's telephone transformer, or translator, as it is called. This is very interesting, from the fact that a closed magnetic circuit is used, and is found in practice to be better than an open circuit. It can be used both to ring up and to talk through, whereas the older form was not applicable to both purposes.

As regards long-distance telephony, some of our visitors may be interested to hear that they can talk through from the exhibition to Aberdeen, a distance of 200 miles, also to Hawick on the south, and to Glasgow, Ayr, and Greenock on the west. In fact, the network of trunk lines for central Scotland is fairly complete, as may be seen by the map which I have here.

In the French Court, amongst several handsome exhibits, there is one of the "roses" used for separating the different subscribers' wires, as they are led into the Central Station, in Paris, from the cables which run along the sewer canals.

Miscellaneous.

It was originally my intention to have devoted a section to the various purposes for which electric signalling is employed as distinct from the interchange of correspondence or telegraphy. This would have included railway and ship signalling and working, fire alarms, watchman's tell-tales, and so forth. My paper, however, has already extended to a length which I am afraid must have strained the patience of my hearers almost to the breaking point, and I must therefore be content to inform those interested in this important branch of electrical development that they will find in the exhibition good exhibits of the most recent devices in actual operation. I may perhaps specially direct their attention to the exhibits of the London and North-Western Railway Company, the Great Western Railway Company, the Eastern Telegraph Company, Messrs. Woodhouse and Rawson, and Messrs. Cox-Walker and Co. I must, however, ask you to bear with me a moment longer whilst I refer to an interesting application of alternating currents by Mr. Rankin Kennedy. It is an "electrical heater" in the shape of a transformer. The primary coil is partly surrounded by a laminated iron core of the usual shape, but the magnetic circuit is completed by the metal of a "flat-iron." This metal, it is needless to say, is not laminated, and therefore forms the secondary circuit, becoming well warmed when an alternating current of 50 amperes flows through the primary coil.

Finally, I must not omit to mention that the turrets at the main entrance and the large hall are protected from lightning by a network of conductors devised by Dr. Lodge. A No. 5 iron wire is run up each of the four corners of the turrets, and is firmly soldered at its lower end to the water-pipes. At intervals the four wires in each turret are connected by horizontal wires, so as to form a complete network; connecting wires are also carried across the front between the turrets. From one of these two, No. 8, iron wires are run along the ridge of the roof of the hall, and connected at intervals to the sheet zinc used for roofing purposes; the ends of these wires are carried down the back of the hall, and firmly soldered to a good earth plate, as there were no water-pipes available at that end of the hall. One is almost tempted to express a wish that we may have a good tropical thunderstorm before the close of the exhibition.

THE LINEFF SYSTEM.

The appendix to Mr. Kapp's report, referred to in our last issue, gives the data upon which he founds his conclusions, and reads as follows:

The tests upon which my report is based were made on the 29th and 30th of May, and the 3rd, 10th, and 11th of June, 1890. I

deal in this appendix with the various points in the same order in which they occur in the report.

Safety to the Public.

The extent of "charged region" on the insulated rail was tested in the following manner: The positive lead feeding the glow lamps on the car was disconnected from the main positive terminal, and connected to a flexible conductor terminating with a contact piece or pilot brush. The latter was attached to a wooden bar, which could be set so that contact was made with the insulated rail at any given distance from the centre of the car. When the point of contact was on a charged or "live" rail the lamps lighted up; when on a "dead" rail they remained dark. By varying the distance of contact it was thus easy to ascertain the extent of the charged region on either side of the centre of the car. I found that the length of charged region varies at different points of the line, which may be due either to a variation in the thickness of the hoop iron (this being of two different gauges on the line), or to a variation in the thickness of its zinc coating, which, if too thin, would not allow the hoop to drop instantly. I also found that there was some uncertainty in the lamp test if the contact between the pilot brush and live rail lasted only a fraction of a second. In such cases the lamp filaments had not time to become so hot as to be distinctly visible, and I replaced in subsequent tests the lamps by an electric bell, which gave indications with contacts of so short duration as to escape detection by the lamp test. The results of these tests, which were made at various speeds and over a continuous piece of line 68ft. long, are given in the following table:

Extent of charged region behind the centre of the car.	Speed in miles per hour. 1	3	7
7 feet 6 inches	live	live	live
8 ,, 3 ,,	live	live	live
8 ,, 6 ,,	live	live	live
9 ,, 0 ,,	dead	dead	dead
9 ,, 6 ,,	dead	dead	dead
10 ,, 0 ,,	dead	dead	dead

There remained still the question whether the wave running along the hoop iron under the car might induce subsidiary waves in it at greater distances than 10ft. from the centre either in front or behind the car. If this were the case there would be danger of the magnetic rail becoming "alive" at points when ordinary traffic passes over it. I have tested this question by short-circuiting the magnetic rail to earth at various distances both in front and behind the car, and whilst the latter was running and standing, and in no single case have I found a "live" section of magnetic rail.

I also investigated the question whether it will be possible to collect the current from the magnetic rail without sparking, as otherwise horses might be frightened. In the original management, the collection of current was effected by the contact of the wheels supporting the electromagnet on the magnetic rail, and with a dry and clean line, or with a dirty and wet line, there was no perceptible sparking. If, however, the line when dry was covered with dry sand, gravel, and clinkers there was sparking, and to avoid this defect, I advised Mr. Lineff to fit wire brushes to the pole shoes so as to obtain more perfect contact. This has been done, and in a subsequent test no perceptible sparking occurred with any condition of line.

Efficiency of Service.

The efficiency of service depends upon the power required to propel the car and upon the possibility of maintaining the line in proper working order. As regards the power required for the car itself, apart from that absorbed by the apparatus for collecting the current, there is no reason why the Lineff car should require either less or more power than any other electric car of equal weight, and geared to run at the same speed. I have therefore only to investigate what extra amount of power is absorbed by the apparatus for collecting the current, and what amount of power is lost by underground and surface leakage.

The power required for the current collecting apparatus may be regarded as lost to propulsion, and this loss consists of three items:

1. *Imperfect Contact between Magnetic Rail and Wheels of Electromagnet.*—I measured the difference of potential between the magnetic rail and the car terminal when the working current of 11 amperes was passing. The drop of E.M.F. thus found varied with the condition of the line. It was ·3 of a volt when the line was watered, but otherwise clean, ·7 when the line was clean and dry, and 2·7 when the line was dirty with mud, horse dung, sand, and clinkers. These tests were all made before the brushes mentioned had been fitted, so that with the improved contact this loss of power may be considered as insignificant.

2. *Power required to Energise the Electromagnet.*—The resistance of the two magnet coils and a third external coil is 220 ohms, and the working pressure 230 volts. The power absorbed in the three coils is therefore $\frac{230}{220}.230 = 240$ watts, of which 160 watts are required for the magnet and 80 watts wasted in the external coil. These 80 watts could be saved by rewinding the two magnet coils with finer wire. The energy expended in "picking up" is therefore 160 watts. I had previously tested the magnet and found that 60 watts is the minimum of energy required for picking up, but to make sure of always maintaining the circuit 160 watts have been allowed. During my test of the line there has been no case of failure to maintain the circuit.

3. *Power required to Propel the Electromagnet.*—This was tested by hauling the magnet alone along the line, a spring balance being inserted into the hauling rope. I found the resistance to be 19lb. when the magnet was not energised, and 27lb. when it was energised. At seven miles per hour this represents an expenditure of about half a horse-power. It appears desirable that this loss of power should be reduced, which can be done either by employing larger wheels and improved axle-bearings on the electromagnet, or by so suspending it from the car, that part of its weight is taken by the car.

In the workshop there has been erected a full size working model of the magnetic rail as arranged for a switch or branch line. After the tests on the line on the 30th of May were completed, the electromagnet was detached from the car, taken into the workshop, and run over the magnetic rail containing a branch line. The current collecting apparatus acted perfectly, and there was no failure to maintain the circuit either on the main or on the branch line.

Economy of Working.

I have now to consider the amount of power lost by underground and surface leakage. The former takes place over the whole length of the line, and is independent of the number of cars in use at any time, whilst the latter is confined to the three charged sections of magnetic rail under each car, and is therefore proportional to the number of cars in use at any time. The insulation resistance of the conductor was tested both by the bridge method (48 Leclanché cells, Post Office pattern bridge, and mirror galvanometers), and by passing the leakage current through a voltmeter. The two methods gave fairly accordant results, but the insulation varied on different days considerably. The highest reading I recorded by the voltmeter test, when the full pressure of 230 volts was on the conductor, was 5,400 ohms, and the lowest 3,550 ohms. In order to maintain the underground conductor in a proper working condition, I consider it desirable and possible to increase its insulation resistance. But for the determination of loss of power by leakage I take the figures as I find them, disregarding any future possible improvements in insulation. From these figures it appears that the average insulation is 4,475 ohms. Since the line is 220ft. long the insulation resistance of one mile of similar line will be 186 ohms. Assuming the working pressure to be 300 volts, the leakage current would be 1·61 amperes, and the power thus lost would be 482 watts, or about two-thirds of a horse-power. This loss in itself is not an important item. It is, in fact, negligible in comparison with the power which is required for the propulsion of the cars on a mile of line.

Another source of loss of power in electric traction is surface leakage. To ascertain this, I also applied the voltmeter test, and found the following insulation resistances of three charged sections of magnetic rail. With the line clear and moist 4,183 ohms; with the line very wet and covered with mud and horse droppings, 980 ohms. Taking 2,000 ohms as an average I find that at a working pressure of 300 volts the loss of power by surface leakage per car amounts to 45 watts, which is quite insignificant.

As regards the question whether it will be possible to maintain the line in proper order when subjected to the wear and tear of ordinary street traffic, I am of opinion this can only be decided by actual trial extending over a considerable time. As far as it was possible to do so in an experiment extending over a few days, I have tested the line both as regards mechanical strength and insulation. I have already mentioned that the resistance varied between 5,400 and 3,350 ohms during the time over which my experiments extended. An average insulation of 4,475 ohms per 220ft., or 186 ohms per mile, would not be too low if the only consideration were that of the waste of power entailed by leakage, but experience shows that when the insulation of a line is initially low, there is probability of its becoming still lower in the future, and for this reason I consider it desirable to improve the insulation of the line. I am of opinion that this can be done in two ways: first, by an alteration in the shape and arrangement of the earthenware supports of the conductor, and, secondly, by blowing dry air through the channel. This will necessitate the employment of air compressor at the power station, but the additional capital outlay and working expenses will be trifling in comparison with the advantages of good insulation, which will be obtained thereby. The mechanical strength of the closed channel was tested by taking a steam roller both across and along the line. Since the magnetic rail is slightly higher than the running rail, and surrounding pavement, the whole weight on one of the driving wheels of the steam roller (which I estimate at five tons) was thus supported by the magnetic rail. The steam roller was driven backwards and forwards, over and across the magnetic rail, to see whether any mechanical damage could thus be done to it. I could not detect any deformation or other damage done either to the magnetic rail or the bitumen channel, and so far the steam roller test was entirely satisfactory. There remained still the possibility, that through the application of a concentrated pressure of five tons, minute cracks, invisible to the naked eye, might have been developed which would admit moisture and thus impair the insulation. To test this point, I had the line drenched with water, but, as shortly afterwards it began to rain, I discontinued the artificial application of water. The rain lasted on and off during the remainder of the day and following night, and in the afternoon of the following day I had the insulation of the line again tested by my assistant. He reported 3,400 to 3,800 ohms. Before taking the steam roller over the line the insulation was 3,400 ohms. If the mechanical strain had developed cracks in the bitumen there would have been sufficient time for water to percolate in the interval of 26 hours which elapsed between the two resistance tests. Since, however, the second test showed the same, if not a higher, insulation than the first, it is evident that no damage was done to the line by the steam roller, and I consider the result of this test very satisfactory.

THE

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FIRE RISKS.

The letter of Mr. Verity and the correspondence that has ensued thereon shows there still exists a feeling of insecurity as to the rules to be followed. It must be remembered that from time to time new firms are entering into electrical work, and especially into wiring operations. Many of these firms know nothing of the history of the fire office rules, and are troubled as to what rules to use to guide them. Mr. Verity points out that it frequently happens three or four companies are concerned in the risk, and as each company may have rules of its own it is difficult to know what to do, as these rules may insist upon the same thing being done in different ways. The plain way out of the difficulty is for all the companies to acknowledge one set of rules, say the Phœnix rules, as suggested by Mr. Howard. Unfortunately, there seems to be something of the "Old Adam" abounding among the fire insurance companies or their inspectors. A few, we believe a very few, prefer to walk alone. No matter how good a bridge has been constructed at great labour and under experienced constructors, they prefer their own construction, following, perhaps, somewhat the same lines, but meandering occasionally. One man thinks it derogatory to his dignity to follow exactly in the footsteps of a predecessor, hence he must, to show his own knowledge and especially his own importance, cut out a path for himself. Mr. Verity suggests following the Institution rules; Mr. Howard fears that they would be found more or less unsuitable. It must not be forgotten in this controversy that, whatever be the weight of the opinion of the Institution, the industry can hardly hope that the insurance companies will accept any other rules than their own. The companies have to take the risk, they have to pay the piper, and we are bound to confess that scientific knowledge and skill stating one thing is insufficient to prevail against the private history of fires as shown by the books of the companies, which say another thing. Further, whatever rules are used require constant supervision and modification. Every new departure requires either a relaxation or a more stringent rule to meet it. If the Institution rules are to be followed, some provision must be made for a permanent committee to hear and consider all the objections and suggestions put forward. Rules satisfactory to-day may not be satisfactory "next" year. The insurance companies, again, would be reluctant to open their private reports to any such committee, and yet upon these private reports rules have to be devised. According to our view then, the subject is one of considerable difficulty. The surveyor or inspector in his ordinary duties continually comes across the weak points, and in the interests of his office he has to see that these weak points are strengthened. What may be regarded as

TABLE C.

Date.	Time.	Cell under test. State.	Cell under test. Temp.	Temperature of Air.	Temperature of Idle cell.	Time from beginning of discharge or charge.	Difference between temperature of cell under test and temperature of idle cell.	Rise or fall of temperature during a complete discharge or charge compared with temperature of idle cell.
1889.	Hrs. min.		Deg. C.	Deg. C.	Deg. C.	Hrs. min.	Deg. C.	
July 10th	1 10	Charged	19·95	18·75	18·6	0 0	1·35	− 1·25 during discharge.
„	11 20	Discharged........... ...	18·6	18·6	18·5	10 10	0·1	
„	16 55	Charging.................	19·6	19·1	18·84	5 35	0·76	+ 1·2 „ charge.
„	21 6	„	19·9	19·0	18·9	9 46	1·0	
„	22 50	Charged	20·2	18·8	18·9	11 30	1·3	
July 11th	7 55	Discharging	18·65	18·25	18·1	9 5	0·55	− 0·70 „ discharge.
„	8 50	Discharged.............	18·8	18·5	18·2	10 0	0·6	
„	11 38	Charging.................	19·05	18·6	18·4	2 48	0·65	+ 0·77 „ charge.
„	15 10	„	19·3	18·8	18·5	6 20	0·8	
„	19 50	„	19·7	19·0	18·7	11 0	1·0	
„	20 25	Charged	20·1	19·0	18·73	11 35	1·37	
„	21 42	Discharging	19·95	18·95	18·85	1 22	1·10	− 1·40 „ discharge.
July 12th	5 40	„	18·72	18·75	18·75	9 20	−0·03	
„	6 20	Discharged.............	18·72	18·75	18·75	9 55	−0·03	
„	7 50	Charging.................	19·3	18·65	18·7	1 30	0·6	+ 1·33 „ charge.
„	10 30	„	19·5	19·0	18·78	4 10	0·72	
„	12 40	„	19·61	19·1	18·77	6 20	0·84	
„	17 45	Charged	20·40	19·26	19·1	11 25	1·30	
„	21 30	Discharging	19·95	19·25	19·1	3 45	0·85	− 0·67 „ discharge.
July 13th	0 22	„	19·7	19·1	19·1	6 37	0·6	
„	2 55	„	19·73	19·2	19·16	9 10	0·57	
„	3 52	Discharged..............	...	...	..	10 7	..	
„	3 58	Just started charging	19·78	19·08	19·15	0 8	0·63	+ 0·77 „ charge.
„	10 20	Charging.................	20·0	19·2	19·15	6 28	0·85	
„	12 0	„	20·05	19·2	19·15	8 8	0·90	
„	14 20	„	20·30	19·25	19·2	10 28	1·1	
„	15 30	Charged	20·6	19·4	19·2	11 38	1·4	

From Table C we see that, while during the charge the cell rises in temperature, during discharge, on the contrary, it actually falls; hence, in spite of the production of heat due to resistance, the cell is actually cooler at the end of a discharge than at the beginning—a result possibly due to the splitting up of the sulphuric acid during the discharge. This cooling of accumulators during discharge, which we noticed early in our experiments, was also observed at about the same time by Prof. Duncan and H. Wiegand in America and described in their joint investigation already referred to.

From the last table we see that the rise of temperature of the cell during charging may, after allowing for changes of temperature of the room, be either about 1·3deg. C. or 0·77deg. C., while the fall of temperature during discharging may have either of the two preceding values. It is further interesting to notice that the rise of temperature during the charging has the higher or the lower of these two values according as the fall of temperature during the previous discharge had the higher or the lower value.

On plotting the differences between the temperatures of the working and the idle cell and the corresponding times given in the last table, we obtain the dotted line 24 (Fig. 8) for the time fall of temperature during the first and third discharge, curve 25 for the time rise of temperature during the first and third charge, curve 26 for the time fall of temperature during the second and fourth discharge, and curve 27 for the time rise of temperature during the second and fourth charges. Twenty-four is dotted, since temperature readings were only taken at the beginning and end of the first and third of these discharges. In the case of the second and fourth of the discharges here referred to, as well as in all the four charges, several observations of temperature were made. From the curves it appears that towards the end of the discharge and at the beginning of the charge one or other of two things may happen—either the temperature in the discharge may go on falling, as in the dotted line 24, or it may begin to rise again, as in 26; whereas, in the charge, either the temperature at the beginning may rise considerably, as in curve 25, or it may only increase slightly, as in curve 27.

It would therefore appear that during the latter part of the discharge one or other of two chemical actions can take place; and these two actions have, for some reason or other, taken place alternately in the four discharges under consideration. But, curiously enough, these four discharges—which took place on July 10th, 11th, and 12th, 1889—occurred with extreme regularity; so that when time curves were drawn, even on a large scale, for each of these discharges, they coincided exactly and produced a single curve, which is shown, greatly reduced, as curve 10 on the sheet of curves given in the earlier part of the paper, And, similarly, for the four corresponding charges the four time curves all coincided exactly, producing a single curve, which is shown, greatly reduced, as curve 11 on the same sheet. It, therefore, seems as if one or other of two chemical actions might take place during the latter portion of the discharge and during the earlier part of the charge, and yet, curiously enough, when the current is kept absolutely constant the time variation of the P.D. is exactly the same, no matter which of these two chemical actions takes place.

About a year later another set of continuous temperature observations was made for many days and nights with the same cells, the current in discharging and charging being, as before, 10 and 9 amperes respectively. The higher P.D. limit was, as before, 2·4 volts per cell, but the discharge was in each case in this second set of continuous discharges and charges stopped at 1·9 instead of 1·8 volts per cell. As the regulation of the current day and night was in these later experiments in 1890 effected by hand, it was not kept quite as constant as when the automatic regulator was employed. Hence the time curves for the excess temperature in discharging and charging, when plotted, were not found to be as regular as in the previous case. But they were quite regular enough to give the general shape of the sets of temperature curves for discharge and charge which are shown in Fig. 9.

It will be observed that in these experiments not merely does the excess of the temperature of the working cell over that of the idle cell fall during the discharge, but it actually continues to fall at the commencement of the charge.

The times of discharging and charging are less than those given for curves 10 and 11, partly because the P.D. was not allowed to run down lower than 1·9 volts per cell in the later observations, and partly because the times of discharging and charging had been diminished by the continued experimental rests to which these cells had been subjected in a charged state during 1889.

The mean temperature of one of our cells is during charging and discharging, roughly, 0·7deg. C. higher than

and 8; whereas, when C_1 were being discharged, mercury cup 7 was joined to 9 instead of to 8. In both cases the current passed along the thick lines through an A. and P. magnifying spring ammeter, whose indications furnished an approximate measure of the current, through an adjustable carbon resistance and a platinoid strip which could carry the maximum current, 10 amperes, used in these tests, without its resistance being perceptibly altered. To two points of this strip were soldered two wires going to the mercury cups 10 and 13: these were joined respectively to 11 and 12 in charging, and to 12 and 11 in discharging, so that the current always went through the D'Arsonval galvanometer, A, in the same direction. This galvanometer then measured the charging or discharging current, its sensibility being such that for a current of nine amperes passing through the circuit a deflection of 600 scale divisions was produced when the resistance in *d* was 185 ohms, that of the galvanometer, A, itself being 52 ohms.

By joining the mercury cups 1 and 2 with a bridge-piece, the P.D. between the terminals of the accumulators under test, C_1, could be measured with the voltmeter, V; the sensibilty being such that with a resistance of 791 ohms in *a*, and 63,696 ohms in *b*, a deflection of 600 scale divisions corresponded with a P.D. of 12 volts. By connecting the mercury cup 1 with 3 instead of with 2, the resistance, *b*, was cut out of the circuit, and the sensibility of the voltmeter, V, was increased 60 times. If now 4 were connected with 5 or with 6, and the sliding contact, S, moved along the thick wire, W W, a point could be found such that no current passed through the voltmeter, V. Next, the main circuit, indicated by the thick wires, was broken, when the spot of light would move quickly across a portion of the scale, and then continue moving right across the rest of the scale. The first part of this motion was of course due to the sudden variation of the P.D. at the terminals of the accumulators C_1 on the current through them being stopped, while the continuation of the motion was due to the subsequent variation of the E.M.F of these accumulators after the current was stopped. And the value of the E.M.F. at any moment was equal to

$$V \pm \frac{0 \cdot 2d}{600},$$

where *d* was the deflection of the voltmeter spot of light at the moment in question, and V was the P.D. between the terminals of the cells C_1 just before the main circuit was broken, and which was measured by the voltmeter deflection when mercury cup 1 was connected with 2. In discharging the + sign was, of course, used, and in charging - sign.

This P.D. at the terminals of the four accumulators under test, C_1, and which had to be balanced by the E.M.F. of the accumulators C_2, approached 9·6 volts towards the end of a charge, while it fell to 7·6 volts at the end of a discharge. In the former case the E.M.F. of four cells and a portion of the fifth of the compensating accumulators, C_2, was employed, while in the latter the E.M.F. of three and a portion of the fourth sufficed. Hence, during the charge mercury cups 4 and 5 were connected together, while during the discharge it was 4 and 6 that were connected together. The portion of the E.M.F. of the last of the compensating cells was, as shown in the figure, obtained by shunting this cell through a platinoid wire, W W, of about two ohms resistance, and making contact with a point of this wire farther from, or nearer to, the positive pole of this cell. This adjustment of the position of S caused very little change in the resistance of the voltmeter circuit, because the resistance of W W was but a small portion of the entire resistance in the voltmeter circuit.

This method of measuring the resistance of accumulators was applied by three of the students of the Central Institution—Messrs. Müller, Stephens, and Wightman—to determine the variation of the resistance during the entire discharge of the cells with 10 amperes, and charge with 9; further, during May and June of this year Mr. Müller has, with great perseverance, been making an uninterrupted series of observations, day and night, to determine the resistance during the entire discharge and charge for various currents. For each of these currents the cells are being brought to a steady working state by many discharges and charges being successively and without interruption made with each current. In the case of the small current the time of a charge and discharge is tediously long, the charge, for example, with three amperes, requiring 40 hours to raise the P.D. from 1·9 to 2·4 volts per cell, so that several weeks have to be spent obtaining the resistance for this current. This investigation of resistance is not yet completed, and therefore we do not propose in this paper to refer to the variation of the resistance of a cell with different currents when the cell is brought to a *steady working state for each current*. Such an experiment has not, as far as we are aware, ever before been attempted with accumulators, former observers having contented themselves with merely observing the variation of the resistance when the current during discharge or charge was abruptly changed from one value to another. This is a very different thing from ascertaining how the resistance of an accumulator varies with the current when *each* of the different currents employed is steadily used for some weeks in the discharging and charging of the cell, until the cell has arrived at a steady working state for the current in question.

We give in Fig. 11 an example of the time fall of the E.M.F. on breaking the circuit for eight periods of 20 seconds during the charge. The curves are all drawn to the same scale, but, in order to get the curves into a

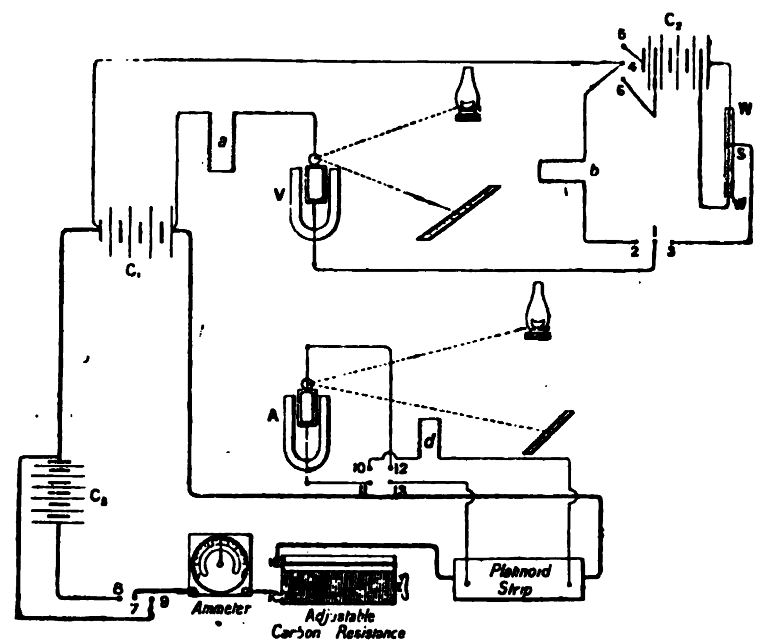

FIG. 10.—Apparatus for Measuring the Resistance of the Accumulators C_1.

and loss account, and the important part of the profit and loss account is that the balance carried to the credit of that account, after making every fair and proper charge against it for the working expenses of the undertaking and proper depreciation of plant, and so forth, presents the very respectable balance of £61,115, enabling the Company to divide, upon the recommendation of the Directors, if you see fit to approve of it, the full 7 per cent. upon the capital, and a very considerable contribution in respect of those years—which were sadly too long at the time, I remember—when there was no dividend to pay at all. You know that the dividend upon the ordinary stock to the extent of 7 per cent. per annum is cumulative—that is to say, in the years when it is not secured by the profits, any balance is carried forward as a claim on the future. We have waited a good many years for that dividend to be found, and last year was the first time that we were able to take some portion of the profits to wipe out the arrears; this year we shall be happy to take a much larger portion. Now, the details of the accounts are these: You will see, beginning on the debtor's side, stock on hand brought forward to July 1, £25,985, and I may as well remind hon. proprietors from time to time that the character of this business demands that a very large amount of capital should be locked up in stock. These lamps, as you know, are of great variety of form and power, and a great many people have a great many different ideas as to what quality and what form they want, and in order to be ready to supply the demand we must have a very great stock of the various lamps on hand in anticipation. If you will cast your eye to the opposite side of the account—I may as well exhaust the subject of stock at once—you will find that a very large increase has arisen, from £25,985 to £56,266; but I will relieve your minds at once by saying that of that large increase only a small portion is attributable to the increased number of lamps, that having kept pace almost in arithmetical proportion with the increased sales. A very large portion of that increase is the price of obtaining platinum, which, with a certain amount of forecast, we have availed ourselves of the opportunity of buying at prices which have been already very considerably exceeded, and that platinum is carried to the account at cost price and is held in reserve; I think it will account for £21,000 of the increase. We found that the demand for platinum was increasing. The supply of it to the market does not appear to keep pace with the increase in the demand, and putting two and two together we thought the price might go up; therefore we laid hands on a considerable amount of it to put away, and the price has gone up considerably since. It stands in the account at its cost price. Well, then there are wages, purchases, etc., £73,719; the cost of conducting the business—salaries, Directors' fees, rent, office expenses, insurance, income tax, general and law charges, £13,915; depreciation on plant, etc., £1,838. Then, on the other side of the account, we have, by sale of lamps, fittings, etc., £118,865; interest, etc., £1,442, and the stock on hand, which I have already adverted to, £56,266. Carrying your eye down, you will see that the difference between the sales, the interest, value of the stock, and the value of the stock on the other side, plus the expenses of the year's business, leaves the balance of £61,115. Then, if you will kindly follow that down, you will see a statement showing the proposed appropriation of the profits; that is a very simple account. On one side is the balance of profit for the current year, £61,115; on the opposite side you will see what we propose to do with it, which is as follows: Dividend for the year ending June 30, 1890, £24,743—you will see that £12,371 was paid as an interim dividend in February. Then comes the claim on the further profit in respect of the arrears. We, of course, keep the account from year to year, and we wipe out the debt against each year, beginning with the most remote one. Therefore we propose the payment of the balance of cumulative preferential dividend on the "A" shares for the year ending June 30, 1884, at the rate of 4 per cent., which comes to £14,139. That does not exhaust it, and therefore we carry it on again and make a payment on account of cumulative preferential dividend on the "A" shares at the rate of 4 per cent. for the year ending June 30, 1885. That means that in the year ending June 30, 1884, we paid 3 per cent., which left 4 per cent. in arrear; that is balanced in the first appropriation. Then in the following year we carry 4 per cent. to June 30, 1885. Having done that, we still have £8,093, which we propose to carry to the reserve fund. Now, coming to the balance-sheet again, there is no substantial alteration in any part of it. The capital remains exactly as it was in the last account; the only figure which will be affected will be that one in the table "B" shares, which you will see are entitled to one-fourth of the profit after the cumulative 7 per cent. on the "A" shares. The particular part of that entry pertinent to the present occasion is the statement that the preferential cumulative dividend of 7 per cent. amounted on June 30, 1890, to £110,769; it is the balance of the amount still to be wiped off out of future profits. Then there are sundry credit balances, £26,257; reserve fund, £4,595—which, if you are pleased to confirm our proposition, will be further increased by £8,093; and then the balance of this £61,000, after having accounted for the £12,371 already received. On the other side comes what you have got for that capital—cost of patents, goodwill, etc., £235,614; that has from time to time been subject to diminution by writing down to realisations of property, and so forth; if you go back a few years you will find a considerably larger total sum. Then against that is "further expenditure thereon" during the year, £2,139. That is in relation to the extension of works, or for expenditure fairly chargeable to capital. Then there is the amount realised by sale of plant, £2,030; that is a set-off again, and so we bring it down to £236,022. As to the amount of "B" shares issued as *per contra*, you know the history of that. The shares were given to Mr. Edison and his friends as valuation of interest in this concern, and some day or other—let us hope at no distant day, for the sake of ourselves—will come in for one-fourth of the profits of the undertaking after the payment of 7 per cent. That, with the considerable sum we have to clear off, is more or less remote, but I do not think it so very remote as might appear. Then we come to the other assets of the concern—the shares of the Manchester Edison-Swan Company, £12,000; freehold property, £33,306; plant and stock, £77,221, including that large amount which I have called your attention to; debtors, £15,203; investments, £27,500; and cash at bankers, £31,563. Thus we may say that not an inconsiderable amount of the capital of the Company really is in the shape of solid pudding. The freehold property (£33,306) is the property of the going concern, embracing, as it does, the lamp factory at Ponder's End, which we bought very cheaply indeed, on which we have spent a sum of money, and which from time to time will have to be extended in order to meet the very great demand for these lamps in the future; that is put in at a very safe figure, for a going concern could only get that land and building now for a great deal more than that amount. The same may be said of the other investments of that kind. Then the plant and stock, of course, mean value. Office furniture is an item which will disappear; it is not very large now. The investments of £27,500 are chiefly in consols and cash at bankers. That, I think, appears a tolerably satisfactory account, and unless you wish me to go into any very great detail, I think it would be wise to end what I have got to say upon it by commending to you the recommendation of the Board to disperse these dividends, giving you the assurance that in the details of these several sums a very liberal allowance has been made under all heads on the debit side, and that the balance which has been brought forward is a balance which is absolutely without charge upon it in respect of any cutting down or holding down of the responsibilities which the current revenue ought to bear. I will now move that the report and accounts for the year ending June 30, 1890, be received and adopted.

Mr. Frederick Richard Leyland (the deputy-chairman) seconded the motion, which, there being no discussion, was put and unanimously agreed to.

The **Chairman** proposed: "That a dividend at the rate of 7 per cent. per annum be, and is hereby, declared on the 'A' shares of the Company for the half-year ending June 30th, 1890 (making 7 per cent. for the year), and 4 per cent. in completion of payment of arrears of cumulative preference dividend for the year ending June 30th, 1884, and of 4 per cent. in respect of arrears of cumulative preference dividend for the year ending June 30th, 1885—all to be distributed in accordance with the provisions of clause 87 of the articles of association."

The motion was seconded by **Mr. Leyland**, and carried.

The retiring Director (Mr. Shelford Bidwell, F.R.S.) was proposed for re-election by the **Chairman**.

Mr. J. Wilson seconded the motion, and it was carried.

Mr. Donovan moved a vote of thanks to the Chairman and Directors.

Mr. Davey seconded the motion, which was agreed to.

The **Chairman** expressed his thanks, and said the real reason why this Company had emerged from what at one time seemed a perilous position was the strong conviction which they all had at the Board that it was worth fighting for, and they had exercised a good deal of courage, combined with foresight and prudence, in insisting on the rights of the Company being upheld. Those rights might not have been upheld, and if so the difficulties of the Company would have been very great. In virtue of the anxieties and cares which rested on them—which proprietors could scarcely appreciate—he felt personally very much indebted to his colleagues for their consistent support and care for the interests of the Company. If they had not felt they had a proprietary who trusted them through good and evil report, they might have broken down; it was their confidence of the shareholders' confidence in them which kept them going, and he was very glad to find they were now in smooth water.

The proceedings then terminated.

MANCHESTER EDISON-SWAN.

The eighth annual meeting of the shareholders of this Company was held on Monday at the Memorial Hall, Manchester, Mr. V. K. Armitage (chairman of the Company) presiding.

The **Chairman**, in moving the adoption of the report, said the Directors were not as satisfied as they might be with the result of the year's operations. Instead of making something over 10 per cent., as they did last year, they had only made something over 5 per cent. They had worked just as hard in making the 5 per cent. as they did last year in making 10. The real fact was that at this moment there was a manifest falling off all over the country in the demand for small separate installations. There was no doubt whatever that electric lighting would increase enormously in the near future; but their strong impression was that the increase would be in lighting from central stations. Parliament had been issuing provisional orders for central stations broadcast all over the country, and there could be no doubt that many people who wished to have the electric light were now waiting to see what would be the outcome of these provisional orders. Before they went to the expense of securing private plant, they were waiting to see whether they could not draw their supply of electric light from a central station, as they did now in the case of gas. At the same time he had not the smallest doubt that in the very near future there would be an enormous increase in the electric lighting industry, and with the experience the Edison-Swan Company had had in this district, and with the name they had acquired

for doing good work, he had not the smallest doubt that, when the increase came, the Company would receive at least its fair share of the work that had to be done.

The motion for the adoption of the report was seconded by **Mr. L. C. Waterhouse**, and carried unanimously.

On the motion of the **Chairman**, seconded by **Mr. Waterhouse**, it was further resolved that the profit of £1,647. 6s. be appropriated to payment of a dividend at the rate of 5 per cent. per annum (£1,000), carrying forward the balance of £647. 6s.

GLOBE TELEGRAPH AND TRUST.

The seventeenth ordinary general meeting of the Globe Telegraph and Trust Company, Limited, was held on Tuesday at Winchester House, Old Broad-street, Sir John Pender presiding.

The **Chairman** stated that during the last three years they had been steadily progressing, but, as the shareholders were aware, they were dependent in this respect on the progress of the submarine telegraph companies in which they were interested. On the whole, they were in a very satisfactory position; and, as he foreshadowed at the last meeting, they now proposed a dividend making 5 per cent., tax free, for the past year, compared with 4½ per cent. for the previous year. During the last financial year they received £198,466, the balance, after deducting working expenses, being £193,499, of which £130,806 had been already distributed, leaving £64,700 now to be dealt with for the final dividends recommended. Taking the combined dividends paid on the preference and ordinary shares during the 17 years of their existence, he found that the average return had been £4. 6s. per cent. For the past year, as he had said, they proposed a dividend on the ordinary shares of 5 per cent., and they hoped they might retain the level which the past year had given them. With reference to their investments, the Atlantic cable companies found that they were carrying as many messages at the shilling tariff as they had previously been receiving at the sixpenny rate. This had materially contributed to the Globe Company's exchequer. They were also largely interested in the Eastern and Eastern Extension Companies, respecting which he might state that the result of the recent Paris Telegraph Conference had not been unfavourable. A good deal had been heard lately of the Imperial British East Africa Company, who held a meeting the other day in London, when information was given as to the work they were engaged upon. Unfortunately they overlooked mentioning that the Eastern Company had laid a cable to connect the East Africa Company's important port of Mombasa with the more important port of Zanzibar; a work done entirely at the cost of the Eastern Company, and entirely in the interest of the East Africa Company. He concluded by moving the adoption of the report and the payment of the dividends recommended.

The **Marquis of Tweeddale** seconded the motion.

In answer to Dr. Pocock, the **Chairman** said that the Directors of the Eastern Telegraph Company, of which he was chairman, hoped that the traffic on the cable that they had laid from Zanzibar to Mombasa would repay them for the outlay. They had, however, at all events, done what they had considered it their duty to do—to follow the flag and encourage as far as they could the development of the country. They would continue this policy wherever they could do so with effect.

The motion was unanimously adopted, and the retiring Directors and Auditors were re-elected.

DIRECT UNITED STATES CABLE COMPANY, LIMITED.

The half-yearly meeting of this Company was held on Friday last, at Winchester House, Sir John Pender in the chair.

The **Chairman** said that at the last half-yearly meeting he gave a very full exposition of the position of the Company, and stated that he was afraid it would be necessary to draw special attention to the reserve fund. During the active competition they had been drawing upon that fund to some extent to supplement the dividends and maintain them at 3 per cent. He now found that it would not be necessary to appeal in any way to the shareholders respecting the fund. It seemed to have turned the corner, and for the first time during the past two or three years they had been adding to it instead of taking from it, and it now stood at a good round sum, which he hoped might be still further increased. They stood in a thoroughly independent position. Their cable stood at a far lower cost than any other in the Atlantic; and, although it was a single cable, they were guaranteed by six others, so that, even if it were broken for three years, they would get a small return. At the present moment, with the shilling tariff, they were carrying quite as many messages as at the sixpenny tariff, but they were not getting that amount of money which such a risky occupation was entitled to, and he hoped something would occur to effect a material economy in the working of the cable. It was a magnificent property, and it would be a reflection on all concerned if they did not manage in some way to give a fair return to their shareholders on what had become a great commercial and political necessity.

The report was seconded by **Mr. W. Ford**, and adopted.

The retiring Directors and Auditors were re-elected, and a vote of thanks was passed to the Chairman.

City of London Subway.—We understand that, by an Act of Parliament recently passed, the City of London and Southwark Subway Company will in future be known as the City and South London Railway Company.

COMPANIES' REPORTS.

EXETER ELECTRIC LIGHT COMPANY.

Directors: Wm. Horton Ellis, J.P. (chairman); Joseph J. Darke; Laurence J. Kennaway; Walter Pring, J.P.; C. J. B. Sanders; G. F. Truscott; Henry Woodgates, M.D.; and Henry George Massingham (managing director).

The following is the report of the Directors presented to and adopted at the second annual general meeting held at Exeter on Tuesday last:

The numerous difficulties which are inseparable from the commencement of every electric light supply company have been successfully overcome. The property which your Directors secured on such advantageous terms as a site for the central station has been thoroughly adapted and fitted up for the purpose, for which its position makes it most valuable. The plant laid down, which has been selected with great care by Mr. Massingham, the managing director, and the electrician in charge, is of the highest possible efficiency and in excellent working order, as is testified by the fact that during the last six months no customer has been deprived for a single hour of the light for which he pays. The accounts show a profit of £165. 6s. 7d., which your Directors recommend should be carried forward. That any profit should have been made must be considered satisfactory, seeing the short time that the station has been in anything like working order, and that neither the arc nor incandescent dynamos are yet being worked to their full capacity. The Company being now well established, and the supply of the electric current perfect, there is every reason to expect that during the next six months all the additional lights which the machines are capable of supplying will be taken up by customers, which would produce a good dividend, to be augmented as the demand for light increases and additional plant laid down. It has been considered desirable to apply to the Board of Trade for a provisional order authorising the Company to supply electricity in Exeter, and the necessary preliminary notices have accordingly been given. This order will place the Company in a more advantageous position for extending its operations, and will empower it to place the mains underground. The auditor, Mr. James Knill, retires, but is eligible for re-election and offers himself accordingly.

Profit and Loss Account to June 30, 1890.

Dr.	£	s.	d.
By rent for lamps and current, electrical apparatus, etc., sold, and installations carried out, including £779. 1s. 3d. not yet paid	2,789	1	7
By stock in hand to June 30, 1890	249	17	8
	£3,038	19	3

Cr.	£	s.	d.
To salaries, offices, etc.	232	15	0
,, wages	264	4	7
,, coal	284	16	0
,, materials for installation	523	18	11
,, renewals and repairs	78	18	7
,, oil and waste	75	4	1
,, installation work	1,239	13	0
,, printing and stationery	9	2	10
,, carriage	11	4	2
,, insurance	8	7	6
,, rates	33	7	9
,, postage and telegrams	19	9	8
,, sundries	15	12	1
,, bank interest	76	18	6
Profit balance	165	6	7
	£3,038	19	3

Balance Sheet.

Liabilities				£	s.	d.
To shareholders	£9,150	0	0			
Less unpaid	186	0	0			
				8,964	0	0
,, sundry creditors				2,207	18	8
,, bankers				3,364	15	8
,, profit and loss account				165	6	7
				£14,702	0	11

Assets.	£	s.	d.
By land, plant, machinery, etc.	13,673	2	0
,, outstanding accounts	779	1	3
,, stock in hand	249	17	8
	£14,702	0	11

CHILI TELEPHONE COMPANY, LIMITED.

Report of the Directors to be submitted to the first ordinary meeting on Friday next.

The Board submits to the shareholders its first annual report and the accounts of the Company to March 31, 1890, duly audited. The whole of the 40,000 shares offered in August last were subscribed for and allotted, and the full sum of £5 has been since received on each share. The purchase-money of the properties in Santiago, Valparaiso, Concepcion, Iquique, Chillan, Talcahuano, Talca, Pisagua, Serena, Coquimbo, Tomé, Penco, Coronel, and Lota, has not yet been paid in full to the vendors. The transfer of these properties was in due course made to this Company by the vendor company in America; but some shareholders of that company, resident in Chili, obtained an injunction to restrain the

legal registration of the transfer, with a view apparently to secure to themselves a larger proportion of the vendor company's assets than would fall to them upon a *pro rata* division with the shareholders in America. The action in the Chilian Court is between the vendor company and a small minority of its shareholders. This Company is not a party to it, but the Board has used, and is using, its best endeavours to remove the impediment to the legalisation of the transfer. Negotiations are reported to be pending to settle the differences by compromise or arbitration; either mode would raise the injunction, and allow registration to be completed. After much correspondence and considerable loss of time, the vendor company appointed this Company's General Manager in Chili to be the general manager of the vendor company there, and, consequently, since that appointment the business has been conducted without serious inconvenience. The business has been carried on for this Company since May 1, 1889, and the net profit to March 31, 1890 (after providing for the extraordinary depreciation in currency) amounts to £5,520. 8s. 1d. The Directors recommend a dividend of 2s. 6d. per share, being a fraction more than at the rate of 5 per cent. per annum from the time the capital has been received to March 31 last; this will leave £520. 8s. 1d. to be carried forward to the account of the next year. The business is progressing satisfactorily.

	May 1, 1889.	March 31, 1890.	Increase.
The number of subscribers was	2,070	2,868	798
The gross revenue was at the rate per annum of	$225,357	$300,346	$74,989
The mileage was	2,523	3,320¾	797¾

The above increases were during 11 months only. The General Manager in Chili has every confidence that, in the current year, very much more favourable results will be shown, and his estimate of improvement is confirmed by a continuous and rapidly-increasing demand for telephones. Negotiations have lately been opened for the sale to this Company of the property, plant, and business of the National Telephone Company of Chili (National Co. Telephonos Chile), in Santiago and Valparaiso, and the Directors have been advised by cablegram of the purchase of the whole for £36,000. That company was the only competitor with this Company, and the Directors having now, practically, the control of the telephone business in Chili, anticipate that the Company's revenue will be considerably increased; while the requirements of the public will be fully met by necessary extensions and moderate and more uniform charges. In accordance with the articles of association, the Hon. F. Ernest Allsopp and Mr. Thomas Greenwood retire from the Board of Directors, but, being eligible, offer themselves for re-election. The auditor, Mr. Thomas A. Welton, also retires, and offers himself for re-election.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the past week amounted to £4,750.

Western and Brazilian Company.—The traffic receipts of this Company, after deducting the fifth payable to the London Platino-Brazilian Company, were £3,679.

Chili Telephone Company, Limited.—The Directors, in their report to March 31 last, recommend a dividend of 2s. 6d. per share, leaving £520 to be carried over.

West Coast of America Telegraph Company, Limited.—An interim dividend of 3s. per share, has been declared by the Board of the West Coast of America Telegraph Company, Limited.

Anglo-American Telegraph Company.—The report shows that the total receipts from the 1st of January to the 30th of June, 1890, including £2,247 brought forward, were £152,989. This amount, however, is subject to revision, as the lawsuit between this Company and the Paris and New York Telegraph Company is still pending. The total expenses amounted to £53,945. One quarterly interim dividend of 12s. 6d. per cent. on the ordinary stock and of 25s. per cent. on the preferred stock was paid on the 1st of May, 1890, absorbing £43,750, and a second quarterly dividend of 15s. per cent. on the ordinary stock and £1. 10s. per cent. on the preferred stock will be paid on the 1st August, amounting to £52,500, leaving £2,793 to be carried forward.

PROVISIONAL PATENTS, 1890.

JULY 21.

11402. **Improvements in couplings for electric railway vehicles.** Louis Pfingst, 45, Southampton-buildings, London. (Complete specification.)

JULY 22.

11438. **Improvements in the means of laying telegraph and other wires, or cables, or pipes underground to facilitate inspection or repair and to avoid disturbance of road or pathways.** Samuel King-Church, 43, Southampton-buildings, London.

11440. **Electric railways.** Frank Mansfield, Norfolk House, Norfolk-street, London. (Complete specification.)

11465. **Improvements relating to riveting by the aid of electricity.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

11480. **Improvements in dynamo-electric machines and electromotors.** Elihu Thomson, 45, Southampton-buildings, London. (Complete specifications.)

JULY 23.

11490. **Improvements in armatures for electrical apparatus such as dynamos, motors, and transformers.** Frederick Henry Royce, Cook-street, Hulme, Manchester.

11499. **Improvements in dynamo-electric machines.** Arthur Ernest Wadley, Winchcombe, Gloucester.

11520. **An improved electric bath brush.** John Pitt Bayly, 18, Fulham-place, Paddington, London. (Robert Williams and Wilbur Shook, United States.)

11533. **An improved electrolytic apparatus for forming copper ingots.** Moses Gerrish Farmer, 151, Strand, London. (Complete specification.)

JULY 24.

11577. **An improved method of propelling carriages by means of electric motors.** John Walker Newall, United University Club, Pall Mall, London.

JULY 25.

11653. **Improvements in and connected with the electric propulsion of vehicles on railways and tramways.** William Edwin Heys, 70, Market-street, Manchester. (Jean Jacques Heilmann, France.)

11657. **Improvements in electric dental pluggers.** William Edwin Gibbs, 6, Lord-street, Liverpool. (Complete specification.)

11679. **An improved electric connection.** William Wilson Horn, 151, Strand, London. (Hercules Sanche, United States.)

11680. **An improved apparatus for producing sheets of metal by electro-deposition.** Moses Gerrish Farmer, 151, Strand, London. (Complete specification.)

JULY 26.

11690. **Improvements in electro-magnetic separators for extracting metal from slag and the like.** Philip Unwin Askham and William Wilson, Sunbridge-chambers, Bradford.

11699. **Process for obtaining chlorine and bromine by the aid of electricity.** George Nahnsen, 89, Chancery-lane, London. (Complete specification.)

11720. **Improvements in connection with electrical fuses.** Reginald John Jones and George Worrall, on behalf of Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London.

11737. **Improvements in posts or pedestals for electric arc lamps, in the arrangement and mechanism of arc regulators, in guide apparatus for carbon holders, and in apparatus for automatically cutting an arc lamp out of circuit.** Frank William Allchin and John Lea, 55, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1889.

11332. **Dynamo electro machines.** Hedges. 8d.

11425. **Electric arc light lamps.** Fischinger. 8d.

11519. **Electric lamps.** Farquhar and Doulton. 6d.

11997. **Electric meters.** Emmott and Ackroyd. 6d.

13001. **Electric fire alarms.** De Poulpiquet. 8d.

13282. **Electric lamps.** Slatter. 8d.

13838. **Electrical currents.** Heaviside and Jackson. 8d.

14086. **Electrical transformers, &c.** Johnson and Phillips. 8d

1890.

4191. **Generating heat, &c., by electricity.** Farrall. 8d.

4949. **Galvanic batteries.** Weigert. 4d.

5764. **Electrical intercommunication.** Thompson (Berne and another). 6d.

6124. **Underground electric conduits.** Munsie. 8d.

6125. **Underground conduits.** Munsie. 8d.

7433. **Telephones.** Vogel and Calkins. 8d.

8362. **Electric locomotives.** Dummer. 8d.

8578. **Electric accumulators.** Johnson (Hering). 8d.

8703. **Electric welding.** Thompson (Coffin). 6d.

8730. **Electric soldering irons.** Miner. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	2
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	10

NOTES.

Why it Costs.—The expenses of an electric company, says a comic journal, may be summed up as current expenses.

A Large Industry.—It is stated that over 8,000 persons are employed in Chicago in electric railway, telegraph, telephone, and electric light service.

Mechanical Engineers.—At the summer meeting of the Society of Mechanical Engineers at Sheffield this week, a paper will be read on "The Elihu Thomson Electric Welding Process."

Increase of Telephones.—The number of American Bell telephones for the month to June 20th last, shows an increase of 1,414. The total number of telephones in use was 466,334, as against 430,476 in 1889.

Personal.—The Hon. A. B. Coffin, of the Massachusetts Gas and Electric Light Commission, is now on a European tour. It is his intention to visit the principal gas and electric plants in this country and France.

The British Association.—At a meeting held in the Council chambers, Edinburgh, the Lord Provost presiding, it was resolved to renew the invitation to the British Association to meet in Edinburgh in 1892.

Anglo-French Telegraphs.—The Paris Chamber agreed on July 31, without opposition, to a vote of 400,000f. for a new four-conductor cable between Calais and Folkestone, and an electric wire between Paris and Calais.

Electric Street Signs.—In St. Louis the name of the street is arranged on the electric light globes so that the shadow falls on a suitable blank wall or other blank space, to be read by people passing. The letters are formed by shadows about 5ft. high.

New Telephone Exchange in Yorkshire.—A new telephonic system outside the present company is being attempted for Yorkshire. It is intended to commence in Leeds, Bradford, Halifax, Dewsbury, and Huddersfield, coupling these towns together and extending to others.

Provisional Orders.—One hundred and sixty-one applications for electric lighting Acts have been made to the Board of Trade during the past year. Forty-five were made by local authorities, 116 by companies or individuals, and 23 related wholly or in part to the County of London.

An Electric Railway in Asia.—It is reported that an electric railway is to be built in Siam, from Bangkok to Paknam, a distance of 30 miles. This road is to cost £80,000, and Siamese capital will be used. An electric light company has also been organised, and the plant ordered for Bangkok.

Electric Works for Bromley.—The local syndicate for the electric public lighting at Bromley, Kent, have resolved that they will not favour any particular company in the carrying out of their scheme, but will employ their own engineer to get out estimates and then invite tenders from some of the best firms.

Estimates for Sheerness.—Mr. Whalebone has given notice to the Sheerness Local Board of Health that at the next meeting of the Board he will move a resolution that communication be opened with electric lighting companies for the purpose of ascertaining terms for the lighting of the public streets of Sheerness with electricity.

Ferranti v. Westinghouse.—The interference appeal case between Ferranti's application of April 18, 1887, and Westinghouse's patent of July 12, 1887, for improvements in electric converters has been decided in favour of Westinghouse, under ruling that a British invention cannot be said to be patented until the final act of affixing the seal.

Who Owns the Earth ?—The question of who owns the earth in an electrical sense is a moot point between electric railways and telephone companies in the States, and often comes into the local courts. It is generally decided the earth is free to whoever likes to use it, and the telephone companies put up metallic circuits, leaving the electric railways in possession.

Lead Poisoning.—A suit has been brought in New Orleans for 10,000dols. damages by a married woman who accepted service in trimming lead in an accumulator factory without being informed it was dangerous. Lead poisoning set in, and her health became completely ruined. The Board of Health have ordered more ventilation, and the matter is expected to go farther.

Telegrams to England.—The Minister of Commerce, when submitting to the Chamber of Deputies a Bill authorising a credit of 400,000f. for laying a new cable between France and England, drew attention to the fact that the number of words transmitted over the existing cables during the past year amounted to 19,930,000, as against 17,717,000 in 1888. Another credit of 295,000f. is asked for to defray the expense of laying new special wires for telephonic communication between Paris and London.

Electricity in Spain.—The second number of *La Ciencia Eléctrica* of Madrid contains a continuation, with illustrations, of the description of the Madrid central station, with other articles. This number also commences a treatise upon submarine telegraphy by M. Wimschendor, translated into Spanish by the editor, Don José Casas Barbosa. Illustrations of the machines of prominent Swiss and French manufacturers appear, and it may form a valuable medium for British electrical engineers to set forth their specialities to Spanish-speaking people.

The Lighting of Dusseldorf.—The *Koelnische Zeitung* in a report from Düsseldorf states that the Corporation of this town have resolved to erect a central electric lighting station for 20,000 incandescent lamps, at a cost of 2,000,000 marks, with direct current and accumulators. The main station is to be built near the new gas works, and two smaller stations in the Bleichstrasse and Grünstrasse. After a paper read by the consulting electrician, Prof. Kittler, of Darmstadt, the execution of the plant was laid in the hands of Messrs. Schuckert and Co., of Nuremberg.

Electric Cabs.—According to our Pittsburgh correspondent, the latest project there is an electric cab company, for which all the preliminary steps of organisation have been taken. There seems to be more of politics than of practical science in the scheme, but no good reason can be found why electric cabs should not be run successfully where the streets are good. Our recollection of Pittsburgh is that its street paving is poor, not offering many opportunities for easy traction. However, the city is, it is said, to have no fewer than 40 electric cabs.—N.Y. *Electrical Engineer.*

Westinghouse Alternating-Current Motor.—The long-looked-for alternate-current motor seems to have

arrived at last. It is reported that the Westinghouse Company are now making a new motor for alternating currents, which they claim, owing to its many advantages over any similar motor, is bound to become a great success. As it does not require any higher tension than an ordinary 50-volt alternating current, its usefulness makes it especially commendable for the running of sewing machines and other minor requirements of power. The company has already received orders for 500 motors.

The Volt Defined.—A daily newspaper in one of the American western cities undertakes to inform its readers in unscientific terms as to the real value of a volt, and does it in this graphic way: "The volt gives one a blow of a specified force. As volts are added together the force of the blow is increased until the endurance limit is reached. It takes about 25 volts to make a perceptible tingling sensation. When 50 volts pass through the body the tingling sensation becomes unmistakable, but not strong, while 100 volts feels lively, 200 volts strong, 300 volts powerful, 400 volts Titanic, and 500 volts will knock a man flat."

West of England Telephones.—We have received the latest edition of the West Counties and South Wales Telephone Company's list of exchange subscribers. The list has grown to a book of 336 pages, and is evidence of the continual energy and enterprise of the company in the extension of their system. The trunk lines radiating from Bristol now are shown on one side to Cheltenham and Bath, and on the other to Cardiff, Swansea, and Merthyr Tydvil. Lines are proposed to connect this centre to London, Portsmouth, and Plymouth; to Falmouth, to Milford and north to Liverpool and Lancashire, to Birmingham and the Midlands,—the latter line being now actively in progress.

Electric Execution.—The murderer Kemmler, after many respites or delays, was at last executed by electricity at Auburn Prison, New York, on the morning of August 6. The event was the occasion of a disgraceful display of excitement not less unworthy than that of a bull fight, perfectly degrading both to the people and the authorities, and we should hope little likely to occur again. The man was pinioned, and the current at 1,800 volts turned on. There was yet evidence of respiration, and the current was again turned on twice more, till smoke appeared from his back and "odour of burning flesh" spread over the apartment in which 26 persons, including newspaper correspondents, watched the sickening experiment.

Croydon.—The Board of Trade have addressed a letter to the Croydon County Council stating that they are willing to allow the Crystal Palace District Electric Lighting Order to proceed, leaving it to the London County Council to oppose it in Parliament; but that the promoters have requested the Board to amend the order by striking out the portion of the borough of Croydon embraced in the area of supply. Under these circumstances, the Board of Trade state that they can only give effect to the wishes of the promoters, and agree to the order being amended as proposed. At the meeting of the Council, some regret was expressed that, this being the case, the portion of Upper Norwood which is within the borough will not be included in the district of supply under the provisional order.

Thermo-Magnetic Apparatus.—Two pieces of laboratory apparatus have been devised, says the *Electrical World*, by J. Stefan, to exhibit thermo-magnetic phenomena. The first, a thermo-magnetic pendulum, consists of a nickel segment attached to the end of a strip of brass, which is movable round a horizontal axis, and is provided above this axis with a sliding weight. When at rest the nickel segment lies between the poles of a horseshoe magnet. On heating one end of the segment, however, that end immediately moves upward, and if the heating is continued a regular oscillation may be started. The second piece of apparatus is merely a nickel disc, which can rotate around an axis passing through its centre of gravity. The poles of a horseshoe magnet cover a portion of the rim, and on heating another portion the wheel commences to rotate, and under favourable conditions can be made to revolve at the rate of 60 revolutions a minute.

Electric Miners' Lamp.—A new electric miners' lamp is reported from Paris, devised by M. Constant Rousseau, manufacturer of electrical apparatus, and is expected to "solve at last the problem so long sought of a portable electric lamp for miners." It does not appear, however, to be vastly different from several fairly well-known lamps of this description, whose descriptions we have given from time to time. The lamp of M. Rousseau contains a Planté accumulator, arranged after the manner proposed by M. Pollak. Externally it forms an upright square, divided into four cells diagonally, and is about the same size as an ordinary miner's lamp. It carries a very small incandescent lamp, protected by a second glass bulb. The weight is about 4½lb., and the duration of lighting is 11 hours. The charge required is 12 hours. The price of the lamp at present is 30f. (24s.) each, but this will be less when made in quantity. A specimen lamp has been submitted to the Société de l'Industrie Minérale, and has been favourably reported upon.

Light of the Firefly.—The nature and source of the light given out by the firefly has long been a puzzle to scientists. Prof. S. P. Langley, of New York, has lately been investigating this question, largely by the use of the spectroscope. He finds the light is substantially from the green side of the spectrum. It is of exceedingly narrow range of refrangibility, extending only from F to C, and culminating in the green, so that it contains no appreciable heat. The amount of heat yielded, as measured with Prof. Langley's wonderfully delicate "bolometer," is less than 1 per cent. of that given out with an equal amount of light from the candle and other common combustible illuminants. That the light produced by the firefly is a chemical product would seem to be indicated by the fact, established by Prof. Langley, that it decreased by the processes which checked combustion, and increased by the opposite that nitrogen quenches it and oxygen stimulates it, while the product of the operation, whatever it may prove to be, is apparently carbon dioxide. It may prove, however, so far as can be judged at present, that these effects are simply those of variation of the vital powers and a resulting variation in intensity of the light.

Four Dynamos Driven Direct.—A method of direct driving of dynamos proposed by M. Hamon is described and illustrated in *Cosmos*, in which four dynamos can be driven without countershafting from one engine, doing away with belts, shafting, or pulleys. The engine is supposed to be of the speed ordinarily met with in factories, about 100 revolutions per minute. On each side of the engine, on the axles, is arranged frictional wheels, in the form of large hollow cones—an inner and an outer—revolving in opposite directions, by means of cogs. Each of these pair of friction cones drives two dynamos, gripping the pulley of the dynamo between the revolving cones. The dynamos are arranged

diagonally to the base of the engine at the four corners of its base, and the employment of the mechanical disposition is thought to give advantages which should warrant its adoption in certain cases where the use of belts is not advisable. We should have thought the use of a larger dynamo driven direct would have sufficiently fulfilled the conditions, but if any engineers are convinced in the words of the description that the method suggested is "a veritable progress," it will be interesting to hear of its employment.

Opening of the Southend Tramway.—Messrs. Crompton and Co., Limited, have started running an electric tramcar along the pier at Southend. The engine, boiler, and dynamo are situated under the arches a foot from the entrance of the pier, and the current is conducted along the central rail for three-quarters of a mile down the pier. The car holds about 40 persons, and travels at the rate of about 16 miles an hour, doing the journey in about three and a half minutes, which takes nearly 15 minutes by horse traction. The line, which has been carried out in a very expeditious manner, was certified by Dr. Hopkinson on Friday last, when he expressed himself highly gratified at the result. On Saturday afternoon, after a few trial runs, it was handed over to the Local Board for public use at four o'clock. Immediately large numbers of people availed themselves of it, and all day on Monday (Bank Holiday) the car was well patronised. As this is a highly satisfactory exhibition of electric traction, situated a short distance from London, it will no doubt be visited by everybody interested in this particular work. Messrs. Cromptons inform us that they are willing to give any information to those who require it and will call at their offices, Mansion House-buildings, before proceeding to Southend.

Institute of Medical Electricity.—Larger and more commodious premises have been taken by the Institute of Medical Electricity, Limited, at 35, Fitzroy-square, W. Increasing work and the need for being nearer the great medical centres of Harley-street and Wimpole-street, induced the directors to make the change. They have taken one of the old-fashioned substantial residences on the Grafton-street side of the square. This contains many large light and airy rooms, well adapted to the purposes of the institute, and the house has been redecorated from attic to basement. The apparatus has been carefully removed from the old quarters at 24A, Regent-street, and new apparatus has been added, so that greater facilities for electrical treatment are now available. We understand that increasing use is being made of treatment by what is termed "Cataphoric Medication," or the passage of drug solutions through the skin by means of electric currents. This method of obtaining strongly localised action has been developed from its experimental stage, and first brought into practical use at the institute under the auspices of Dr. Arthur Harries and Mr. H. Newman Lawrence, and we are told that it has already proved very successful. There is evidently large scope for the work of the institute, and the success already attained promises further progress.

Electrolytic Manufacture of Vermillion.—The following process is given in the *Moniteur Industriel* for the production of vermillion by electrolysis: On the interior surface of a wooden vessel, 3ft. in diameter and 6ft. high, circular shelves, about 6in. deep, are arranged, upon which mercury is placed to the depth of ⅜in. These plates are connected to the positive pole of a dynamo. At the bottom of the vessel is a plate of copper, electroplated with steel, and connected with the positive [? negative] pole. The vessel is filled with an 8 per cent. solution of ammonic nitrate and 8 per cent. solution of sodic nitrate. A syphon pierced with holes conveys a constant and regular current of gaseous hydric sulphide; the excess of this gas escaping through a tube traversing the cover. A helical agitator maintains the components of the fluid in a state of perfect admixture. When the electric current passes, a red precipitate of sulphide of mercury is immediately formed. An attempt has been made to dispense with the hydric sulphide by making the bath consist of:

Water	100 litres
Ammonic nitrate	8 kilogrammes,
Sodic nitrate	8 ,,
Sulphide of sodium	8 ,,
Sulphur	8 ,,

Under these conditions it is only necessary to add sulphur and mercury in order to obtain at the end of the operation vermillion which is comparable with that obtained by means of ammonic sulphide.

Boston Electric Railway.—The West End Railway Co. is making good progress in its work of equipping street railway lines in Boston, U.S., for electric traction. The system when completed will have a total extent of over 250 miles, covering a territory nearly 100 square miles in extent. The new rails weigh 74lb. per yard, and are laid on stringers resting on cross-ties. Up to date the company has laid about 100 miles of this track, 52 of which have been laid during the present year. About 800 men are now engaged in the work of track reconstruction. The following details of the central power station are given in the N.Y. *Engineering News*. The foundations will be of heavy masonry resting on piles. The chimney will be 250ft. high, 27ft. 8in. outside diameter at the base and 17ft. at the top. About 30ft. have now been completed. Power will be furnished by 13 triple-expansion Reynolds-Corliss engines, each of 1,750 h.p. Each engine will run four 300 h.p. dynamos, or a total 15,600 e.h.p. Another central station of about 9,000 h.p. will be located in East Cambridge, where works have been purchased by the company. The temporary stations erected to furnish power for the lines now in operation while the new lines are being erected are of no small capacity. On the night of July 4, when the great crowd who went out to witness the fireworks was riding home, the ammeter is stated to have showed a total of about 3,900 h.p. generated at the central station.

Unit of Self-Induction.—The American Institute of Electrical Engineers are intending to take up the question of the name Henry as a unit of self-induction. At the last meeting it was resolved that the name of Henry should be given to the practical unit of self-induction, since he was the discoverer and greatest investigator of this phenomenon, and because this unit at the present time is called a quadrant, which is merely a numerical value, and not a suitable name; and that the institute recommend to electrical societies and electrical engineers the general use of the name Henry for the unit of induction as being the quickest and surest way to secure its final adoption. It is unfortunate, says the official note, that the name of Henry for the unit of induction was not adopted at the Paris Electrical Congress of 1889. If the attention of the congress had been forcibly called to the fact that Henry discovered self-induction, and that his work on both self and mutual induction was of the greatest importance, his name would probably have been adopted then. Henry's discovery of self-induction, which is, of course, the fact that gives the

strongest claim, was made in 1832, and published the same year in *Silliman's Journal*. In that paper he described experiments showing that the spark obtained by breaking a circuit composed of battery and a long wire is greater than with a short wire, and that the spark is further increased by coiling the wire. He then clearly states that the phenomenon is due to the action of the current on itself, all of which is perfectly correct, and would be a good statement of the facts even at the present time.

Electric Canal Traction.—An electrical engineer of Buffalo has been suggesting a scheme for reducing the cost of transportation on the Erie Canal. His plan is to apply an overhead line and trolley in the same way as for street railways to the canal. If the overhead trolley system can be applied to street railways at a cost of about half that of horse power, he argues, why can it not be made to take the place of canal horses with a similar reduction in cost? The poles and other appliances for the overhead wires, and, in fact, the whole plant, covering the entire length of the canal, could be readily arranged without hindrance to navigation. Power stations could be placed as to work sections of 30 miles on either side, being 60 miles apart, and at some points water might be utilised. To obviate the wash from propellers he suggests the use of a twin screw wheel or a wheel working low in the water. The electricity might be used to light the canal as well as the boats, and a telegraph system could be arranged on the poles used in supporting the trolley wires. One man could handle the trolley, and at the same time care for the rudder. In Paris, we remember, there is a long canal line with a constantly moving overhead steel cable for canal boats to hitch themselves to. If such a method as that paid with the constant and heavy loss of power, it is certainly possible that canal traffic might be propelled electrically. There is a tendency at the present to revive canal traction for heavy work. If such a scheme as that suggested could be tried on the large canals in the States, it might demonstrate the way in which other countries could utilise electricity for canals.

Sims-Edison Torpedo.—The following details are given of the Sims-Edison torpedo, recently tested before naval and military experts in America. The torpedo has a long, thin, cigar-shaped body, which contains at its point the dynamite charge; in the centre a drum of two miles of electric cable, and at the rear the motor to which the propeller is fastened direct. The cable is paid out as the motor progresses, and no drag is therefore experienced by the conductor. A float like a long, thin racing boat, is connected to the torpedo, and keeps it a few feet under water, this float being hinged, and made raking so that it can dive under logs or similar obstacles. Two flags or posts serve as guiding marks. On the trial the torpedo ran out into Long Island Sound, a distance of one mile, in three minutes, and was under the complete control of the dynamo man on the shore station. A speed of 22 miles an hour has been obtained. The motor at full speed can absorb 30 h.p., available for propulsion. The torpedo is built in four sections, which can be taken apart or put together in 15 minutes; and none of these parts weigh over 500lb. In working from a shore station the length of reach would be two miles. On a warship the idea would be to have two torpedoes to accompany the vessel, driven from its dynamos, and on approaching an adverse vessel to stop the ship itself and send forward the torpedoes to blow up the enemy. When the torpedo strikes and its motion is arrested the extra strain thrown on the motors is indicated at once on the ammeters. The charge, of 250lb. to 500lb. explosive, is exploded by reversing the current. The steering is done by a polarised relay.

Theory of Magnetic Lines of Force.—The following abstract is given in the *Journal* of the Institution of a paper by K. Kahle, "On the Theory of Magnetic Lines of Force," in the *Elektrotechnische Zeitschrift* (vol. 10, pp. 466 and 527, 1889): The author's object was to test experimentally the theory of electromagnetism which has been developed by J. and E. Hopkinson and G. Kapp. Two bars of soft annealed Swedish iron were bent into the form of horseshoes with parallel limbs, and each limb was partially surrounded by a magnetising coil. The electromagnets were then placed with their poles facing each other, first in contact, and then separated by measured small intervals. The number of lines of force for various current-strengths were then determined at the poles, at the bend, and over the magnetising coils by means of secondary coils and a ballistic galvanometer. The distribution of the lines of force was also observed directly by means of iron filings, and photographs illustrating the results obtained are given in the paper. The results of the observations were in agreement with the theory under consideration when the interval separating the poles was small, but deviated more and more from those calculated from theory as the interval increased. The author attributes this to the method of measurement employed not being adapted to give correct results when the distribution of magnetic force is of the complicated character, indicated by the iron filings for considerable intervals between the poles. This, however, is not of very great practical importance, as in any properly constructed dynamo the ratio of the interval between the poles to their cross section would be small enough to bring them within the limits within which the results deduced from the observations are in agreement with the theory.

A Runaway Electric Car.—A graphic account is given in a Baltimore paper of a runaway electric car which, fortunately, did not kill anybody or even do any damage, though it doubtless well frightened the passengers. "It was a North-avenue car, leaving at 8 o'clock in the evening and was crowded with passengers, who were packed inside and on the platforms like sardines. The conductor on the rear platform yelled 'All aboard?' and released the brake. The machine moved off, gaining speed every second. It was dusk, and persons on the road could not be recognised from the car. When the machine got a start of a couple of hundred feet, a man was seen running after it, waving his arms frantically and yelling vociferously. The conductor waited awhile to see if the man wanted a ride very much before he touched the bell cord. The man acted as though his life depended on catching the car, and the conductor pulled the rope. On sped the car at an increased rate of speed. A second passed, two, three, four, and still the car did not slack. The conductor pulled the rope again viciously, thinking the engineer did not hear the first ring. A third time the bell was rung, and still the machine was increasing in speed and was descending a long and steep grade. The conductor leaned over the side of the platform, and yelled at the engineer, but received no response. The posts along the route flew by rapidly, and the car was moving at the rate of 30 miles an hour. The conductor tumbled over the persons standing in the car as he rushed through to the front platform. No engineer was there. The brakes were found to be unmanageable, and the car could not be stopped until it ran some distance up the next hill. The car stood there five minutes, when the engineer,

George Glenn, reached it, out of breath. He was the man seen waving at the car at the terminus, and the car rushed masterless at a terrific rate of speed down a steep grade for more than half a mile." The car wanted an automatic brake to act beyond a certain speed like that recently tested at Grimsby. An arrangement of this kind is a necessity where there are steep inclines.

Chamber of Commerce.—On Wednesday the Electric Trades Section of the London Chamber of Commerce held their last summer meeting before the holidays. The first business was to receive the resignation of Mr. Trotter, who had accepted an appointment elsewhere. The regret of the members was expressed for the loss of his services, and their indebtedness for a great deal of irksome work and investigation in the matter of railway rates, screw cutting gauge and other questions. Major Flood Page said that he and Mr. Garcke would have something to propose as to the further carrying on of the duties next meeting. The next question dealt with was the Board of Trade regulations for overhead wires, especially as regards regulations 9 and 12. These stipulated that every high-pressure aerial conductor must be insulated to the thickness of at least $\frac{1}{10}$th of an inch, and that when the pressure exceeds 2,000 volts the thickness of insulation must be not less in inches than the number obtained by the volts divided by 20,000. This regulation, it was found in the case of parallel alternate transformer distribution, produced a monstrosity—the No. 13 and 14 wire used on some installations with $\frac{1}{10}$in. insulation was a ridiculous object, while the regulation would in some cases cause the cost to be raised from £28 to £75 per mile, which in a contract of 40 miles was a serious matter. The Board of Trade has been written to, and had replied that they must refuse to change the regulations, as the safety of the public was their first consideration, but any installation would be considered on its merits. It was decided to form a committee of professors with manufacturers and users of wire to meet the Institution of Electrical Engineers, and the following resolution was moved: "That the chairman be requested to draw up a short statement of the disadvantages and hindrance to the electrical trade of some of the Board of Trade regulations, together with the resolution which has been also sent to the Board of Trade, and with a copy of the letter from the secretary of the Board of Trade, and send them to the Institution of Electrical Engineers, with a request that they will appoint a committee to meet a committee of this section to discuss the questions involved, with a view to getting the Board of Trade to reopen the subject." The request of the Chemical Section to consider the amendment of the disclaimers in patent law was considered, the point being that a person could now patent a number of things he had not tried—chemical, or other combinations—and afterwards disclaim them. Mr. Swinburne advised the total abolition of the disclaimer rule. It was resolved that if the Chemical Section held a committee the Electric Section should send representatives. The Frankfort Exhibition was the next question on the agenda, and it was stated that proposing exhibitors should notice that the time for receiving foreign exhibits had been extended to September 30. In answer to the request for appointment of jurors at the Edinburgh Exhibition it was resolved that the notice was too late for anything now to be done, and the section could not therefore undertake to nominate jurors. The report with reference to the decision as to railway rates by the Board of Trade was presented by Mr. Trotter. The gist of the recommendations as affecting electrical trades we give elsewhere. The section will not meet again till October.

St. Pancras : Tenders Accepted.—A special meeting of the St. Pancras Vestry was held on Wednesday to consider the report of the Electricity Committee recommending the acceptance of tenders amounting in the aggregate to £50,946. 4s. 3d. for the establishment of an electric light station and distribution for 10,000 incandescent lights of 16 c.p. and 40 arc lights. Mr. W. H. Preece, F.R.S., who had examined the plans and specifications prepared by the Vestry's engineer, Prof. Robinson, and approved by Dr. Hopkinson, regarded them as "very complete, thoroughly considered, and well worked out." Mr. Preece commended the course pursued by the Vestry as "wise," and the system —the direct continuous-current system—which they had adopted was, he said, likely to "obtain all the results that have been foreshadowed. The ratepayers will secure the light at the cheapest rate, and the profits accruing from private lighting can be devoted either to the reduction of rates or to the expense of public lighting." Replying to Mr. Clements, Mr. Andrew Sweet, the chairman of the committee who had moved the adoption of the report, said the Vestry by its provisional order was empowered to charge 7d. or 8d. per unit. It was allowed to make 7 per cent. profit, and when this was reached the consumers were entitled to a reduction of the cost of the light. In one of the committee's reports it was suggested that the electric light could be supplied at 4½d. per unit. The London County Council had already lent the Vestry £10,000 to acquire the site in Stanhope-street for the purpose of an electric station. Mr. Clements said the promises and hopes on which the Vestry were induced to accept the scheme of electric lighting had been already falsified. Originally, Mr. Gibb, their vestry clerk, estimated the entire cost at £50,000. That was to provide 10,000 incandescent and 90 arc lights. The 90 arc lights had dwindled to 40. They had no estimate in the latest report of what the profit would possibly be. Including the cost, repaying principal and paying interest on the loan to be secured—the loan being for 30 and not 42 years—and allowing £5,000 for extras, he estimated that the Vestry, if they adopted the report, would commit itself to an expenditure of £71,000. He doubted whether the County Council would be able to advance the Vestry a loan for £50,000 for the purposes of electric lighting. Mr. Crow proposed an amendment that the report of the committee be referred back to the committee, and that the further consideration of the report be adjourned until a fresh estimate has been presented. He contended that a private company could supply the electric light better than a public body, and that private individuals could do so better than either. Upon a division after discussion, the amendment was negatived by 47 to 7, and, in the result, the original motion for the adoption of the committee's report was carried, and the necessary tenders were accepted. The tenders are as follows: 1. Buildings, Kirk and Randall, £4,629; 2. Boilers, etc., The Babcock and Wilcox Company, £3,674. 10s. 6d. 3. Engines, dynamos, etc., Willans and Robinson, £16,327. 4. Switchboards, Electric Construction Corporation, £1,313. 1s. 9d. 5. Batteries, Electric Construction Corporation, £2,745. 12s. 6. Trenches for five miles of mains, Mowlem and Co., £9,501; and 7. Electrical conductors, five miles for private lighting, and five and a half miles for public lighting, Clark, Muirhead, and Co., £12,756; total, £50,946. 4s. 3d.; add for royalty, £909; total, £51,855. 4s. 3d.

INCANDESCENT SYSTEM AT WEYBRIDGE.

BY ARTHUR F. GUY, A.M.I.E.E.

Arc lamps are all very well where the lighting is for large and populous towns, or even small ones, provided that the streets are of a nature to justify a good illumination; but in districts where there is scarcely any vehicular or pedestrian traffic this sort of lighting is unnecessary and entirely out of the question. As a rule, the inhabitants of such places retire to rest at early hours, and towards 10 p.m. there are only a few persons scattered about, most of them making their way homeward, the result being that at midnight one might walk from one end of the town to the other without scarcely meeting a soul. Owing to this fact, a great number of towns have their light supply cut off at midnight whether the illuminant be gas or any other.

An arc lamp gives a magnificent light, but it is mostly wasted until it fulfils some purpose where its light can be utilised to the full. What is required, therefore, is a smaller light placed at smaller distances apart, and one that should give an illuminating power superior to that of a single gas jet.

This desideratum is supplied by the incandescent lamp, and its utilisation is excellently shown by a new system just introduced into England by the Laing, Wharton, and Down Construction Syndicate. The system, in a few words, consists in running incandescent lamps in series from off a constant-potential high-tension alternating current on the Thomson-Houston system. The whole arrangements are most novel and complete, and give a solution to the troublesome problem how to run a constant load with a constant current, such as for the town lights, and how to run a variable load at a constant potential, such as for private supply, both supplies to be from one and the same machine, and high-pressure alternating currents to be used in both cases.

The details of this system are given further on. The central station has been designated as a model one, and it deserves the name. The town of Weybridge was first publicly lit up on February 1, 1890, and claims to be the first town in the United Kingdom lighted throughout by electricity, previous to which the town had no light whatever, and it must be most gratifying to the syndicate, as well as to the electrical profession generally, to know that the inhabitants are charmed with the light. This can be understood when it is stated that not a hitch or failure of any kind has occurred since the commencement, and this will go far towards restoring public confidence in the electric light.

The generating station is close by the bank of the Wey, and at some little distance from the centre of the town. The building is of brick, and about 80ft. by 40ft. and divided into four parts—1. Boiler-house. 2. Dynamo-room. 3. Stores and workshop. 4. Office. At present there is only one boiler, although there is room for two more. It is of the Babcock and Wilcox type, capable of developing 90 i.h.p., at pressure of 140lb. per square inch. Feed water is available from two sources; it can be brought from the River Wey by a donkey pump, or else from the water works. In the latter case an injector can be used in addition to the donkey pump. The feed water passes through a steam heater before entering the boiler.

Motive power is supplied by a duplicate set of steam engines, of a vertical, compound, non-condensing type, manufactured by Messrs. Brownlett and Lindley, of Salford. Each is capable of indicating 75 h.p., piston stroke being 11in., connecting steam-pipes are in duplicate. A grooved flywheel of 6ft. diameter transmits power to the alternators by means of an endless cotton rope of three quarters of an inch diameter, consisting of eight turns. Midway between the flywheel and the dynamo pulley a jockey pulley is bolted down at an oblique angle to a concrete block just below the floor: this serves to guide the rope from the extreme right-hand groove of the flywheel to the extreme left-hand groove of the dynamo pulley. A plunger is provided, worked by hand, to eject any condensed steam that may have collected in the pipes from the previous night's run. One particular feature in this engine is that the oiling is effected by sight feed lubricators, so arranged that every part can be oiled whilst running. A relief valve is situated at the top of both high and low-pressure cylinders, and the governor employed is of a very light make, having a sensitive action. Each engine drives a Thomson-Houston alternator of 500 lights capacity. Each alternator has its own exciter.

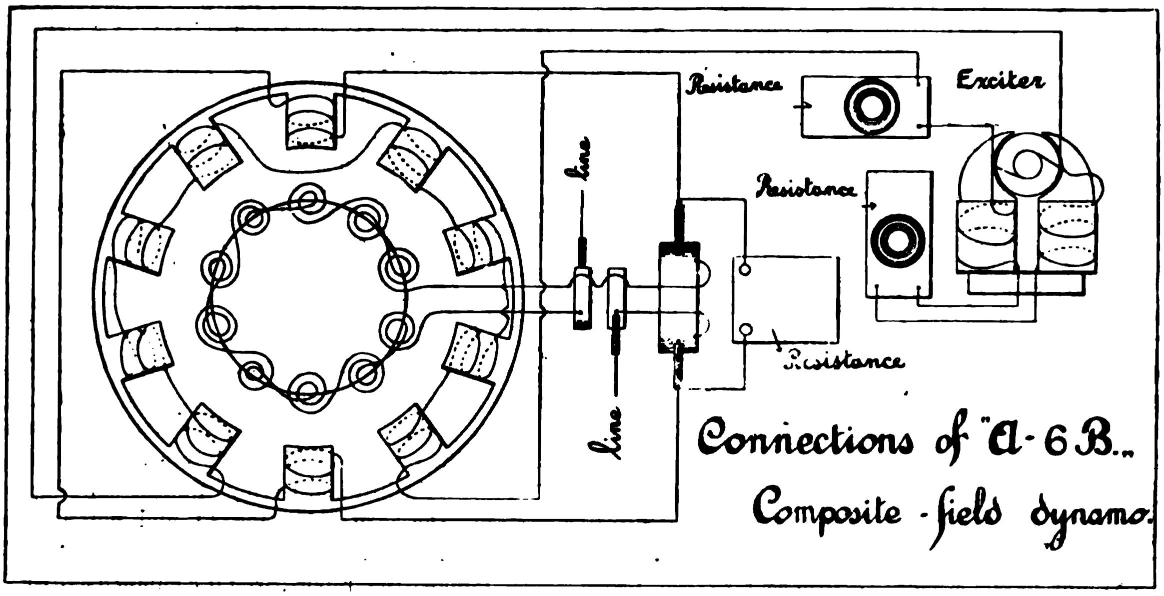

FIG. 1.

The alternators in question are of a new type, and exhibit many interesting features. The connections are shown in Fig. 1. The field-magnets are stationary, and comprise 10 poles, projecting inwards and radially from the yoke. The coils are wound on spools of brass, which are slipped over and fastened firmly in position, the coils being connected up in series by a contact screw. Thus each coil can be easily removed by taking off the upper half of the field casting. The journals contain a spherical box, so as to secure perfect alignment of the shaft in its bearings. The armature is of a drum shape, and has only one layer of wire. In consequence of this there is ample room for insulation and ventilation. The method of winding for the field is entirely novel. The field is made what is termed "composite," that is, it is produced by two separate windings, so as to make the alternator self-regulating, just like a continuous-current compound dynamo. Upon referring to Fig. 1, the nature of the winding can be at once understood. The exciter is shunt wound and has a rheostat in both the external circuit and in the shunt circuit; the rheostats are worked by hand, and serve to vary the current strength delivered by the exciter. The object of having one in the

shunt coils is to obtain a greater range, since a small variation of resistance in the shunt is equivalent to a large one in the external circuit. Running at a speed of 2,200, its maximum capacity is 100 volts and 24 amperes; to maintain a potential difference of 1,000 volts in the primary circuit of the alternator when there is a full load on, requires a current of 5·8 amperes in the field. The continuous current of the exciter is sent round eight of the 10 magnet coils, the two exceptions being the extreme top and bottom coils, as shown in Fig. 1. These two coils are excited by a portion of the current from the alternator, for which purpose it is first led to a commutator, which is fixed on the same spindle, beyond the collector. The collector has one pair of brushes and the commutator two pairs. Across the terminals of the commutator is placed a fixed resistance to form a shunt; this is to provide against loss or drop of voltage along the line as the current rises, and is adjusted so as to compensate within 4 per cent. The rest of the armature current passes into the collector, and so on to the external circuit. This compounding of the field makes the alternator self-regulating, but when the load is varied suddenly and very much—such as when half the lamps are cut out—then the alternator requires some little assistance for regulation, and so the rheostats in the main and shunt circuits of the exciter are brought into use and the current delivered varied. The rheostats can fulfil another duty, since should it be requisite to suddenly cut

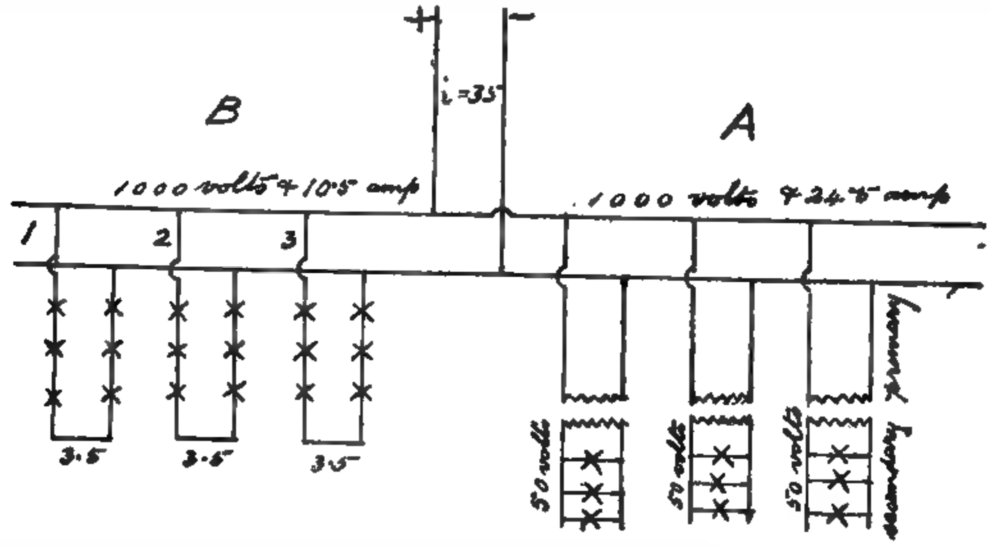

FIG. 2.

FIG. 3.

down the current, owing to any emergency, it can be done instantaneously by their means.

Fig. 2 shows the connections for running town lights and private lights off the same alternator. The method of doing this is as follows: the alternator gives a maximum current of 35 amperes at 1,000 volts pressure in the primary; two parallel circuits are taken from the mains.

A represents private supply mains,
B " town " "

A must be kept at a constant-potential difference of 1,000 volts for house lighting. Transformers supply to the secondary circuit with a variable current of 50 volts pressure, provided that lamps of 50 volts are used. B is also at a constant pressure of 1,000 volts, because it is in parallel with A. Now the current of 35 amperes will divide according to the number of lights in each parallel; since the public lamps are of 20 volts, therefore there must not be more than about 40 of them in series, allowing for loss of potential through line resistance. The lamps take a current of 3·5 amperes, so that there must be a number of circuits in parallel with B, each of which can feed 40 lamps and absorbs 3·5 amperes.

In the case of Weybridge there are 111 incandescent lamps, taking 20 volts and 3·5 amperes, hence there are three circuits springing from the town supply mains. In each circuit there are 37 lamps, and a rheostat is in circuit to regulate the current, which must always be kept at 3·5 amperes; this is shown by a suitable current indicator, whose needle is perfectly perpendicular, opposite the scale

FIG. 4.

mark when the current strength is right. Should a lamp go out then the current tends to rise slightly, but out of 37 lamps $\frac{1}{37}$ increase scarcely affects the rest. However, the indicator is so sensitive that it swings on one side, and the rheostat for that circuit compensates for the lamp. Of course, if there were no private supply, then the whole current could be used in B, and so 10 circuits, each taking 3·5 amperes and feeding 400 lamps, would be available. Since there are three circuits at Weybridge, therefore this leaves $35 - 10·5 = 24·5$ amperes for the private lighting mains A, and since the ratio of transformation is 20, this leaves, allowing for

line resistance, about 400 lamps of 20 c.p. running at 50 volts pressure for private house-lighting. Hence in this system both styles of lighting can be run from off one machine, besides which, owing to the street lamps being in series, there is a very great saving in copper. This is an important item, for 15 miles of wire are used for the 111 street lamps. No. 14 B.W.G. wire is used, having a depth of $\frac{1}{10}$in. insulation. The supporting poles are from 35ft. to 50ft. high, and the lamps are hung on every other pole in the outlying districts, and on every pole in the centre of the town, distance apart of poles being about 50 yards. Steel wire suspenders are used throughout. The height of the lamps are 15ft. above the ground. A light iron bracket abuts from the pole so as to throw the lamp forward. White pot reflectors are used.

Improved and novel constructed measuring instruments are adopted, being of the Thomson-Houston type. Fig. 3 shows a current indicator. The deflecting coils are carried by a pair of circular brass bobbins, dimensions being similar; they are fixed in the same plane, but their axes do not coincide, although their horizontal diameters are in the same line. Parallel with and between the two coils is fixed the deflecting needle. The advantages of this construction is that there is no iron in the bobbins, and they never require any recalibrating. The current indicators are wound with thick wire and the potential indicators with fine wire. Each bobbin has a radial slit, in the bottom of one and the top of the other; this serves to diminish eddy currents. Thomson-Houston double-pole switches are used; they are of the knife-blade pattern, and provided with springs to hold the lever firmly in a horizontal position when switch is open. They are designed so as to permit of a change over—that is, by raising the lever to a vertical position throws one machine into circuit, and by simply bringing the lever downwards to a vertical position substitutes the other machine.

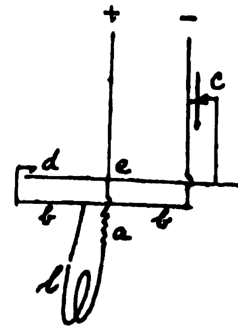

FIG. 5.

A very valuable addition to the system is the Thomson-Houston lightning arrester; it is absolutely essential that every central station should be provided with some sort of arrester, otherwise great danger is incurred, for not a few stations have been wrecked by lightning. Fig. 4 shows the pattern used. The principle of its action depends upon the fact that an arc is repelled from the poles of a magnet. The coils of an electromagnet are inserted in the main circuit, and one pole of the electromagnet is connected to earth, while the other is connected to the line; thus an arc produced by lightning is immediately broken. The most important feature, perhaps, in this system is the series incandescent lamp, and the novelty lies in the cut-out. Fig. 5 gives a diagram of the connections, *a* and *b* denote the two brass terminals of the socket, one being in the form of a screw thread, *a*, and the other a spring plate, *b*; when the lamp is screwed home on the socket, it presses down the spring plate, and so breaks connection at *d*, the current entering at + passes by *a* into the lamp filament, *l*, and by *b* back to −; *c* shows a by-pass or short circuit, and it is kept open by a thin piece of parchmentised paper, one terminal of the short-circuit being a point pressing on the paper by means of a spring, the paper resting on the other terminal—a disc. When the lamp is burning no current passes through *c*, owing to the high resistance of the paper insulator, but should the lamp fail or become broken, then the high pressure of 1,000 volts breaks down and pierces through the paper resistance, thus finding a path for the current.

In the running of the exciter and alternator there is a remarkable absence of sparking, scarcely any wear being perceptible on the commutators and collector. For house circuits okonite wire is used, and a word for its good insulating qualities may be given, when it is stated that an alternator was run for a week through a circuit of okonite wire placed in the River Wey. This wire is composed largely of indiarubber mixed with one of the last residuums of petroleum, the result being that it has very high insulating qualities coupled with the fact that it is unaffected by heat or atmospheric actions.

In conclusion, it may be stated that Weybridge affords an excellent example of how our towns and villages may be lit by incandescent lamps. Owing to the short period during which it has been running, no details can be given as to cost of maintenance, although it may be stated that each lamp costs the town £2 burning until 1 a.m., or £222 per annum for the total.

ELECTROLYSIS OF ANTIMONY SALTS.

BY ALEXANDER WATT.

(Concluded from page 34.)

28. *Chlorides of Antimony and Ammonium by Electrolysis.* A solution was first prepared as follows: Sal-ammoniac (240 grains) was dissolved in 10 ounces of water, and to the solution was then added half an ounce, by measure, of hydrochloric acid. An anode of antimony, connected to the positive pole of a two-cell Daniell battery, was then immersed in the liquid, while a brass plate attached to the negative pole served as the cathode. In about 15 minutes after the immersion of the brass plate it was found that a film of a pinkish hue, interspersed with shades of blue, had formed upon its surface, the edges of the plate being strongly marked by the latter colour. This coloured film adhered very firmly to the brass, and presented a very pleasing appearance. It was noticed that when the film was briskly rubbed with the finger, metallic antimony of the usual colour came into view. It was also a noticeable fact that red and blue were the only colours which appeared under the circumstances referred to, the same peculiarity presenting itself when other plates were subsequently immersed in the same liquid during its electrolysis. It is probable that a solution of this kind might be useful for colouring small fancy articles of brass. A freshly-prepared plate was now placed in the bath and allowed to remain undisturbed for about half an hour, when it was removed and examined, and found to be coated with a film of a dark brown colour. On rubbing the plate with the finger, the brown film readily became removed, exposing a metallic film of antimony of a dark blue-grey tint. When decomposing a solution of sal-ammoniac by a powerful current, Marchand* observed that faint detonations were heard "arising from the formation of antimoniuretted hydrogen." The explosive character of antimony during electrolysis has since been rediscovered by others.

29. *Acetates of Antimony and Ammonium.*—An acid solution of acetate of antimony, prepared by electrolysis, was partially neutralised with carbonate of ammonia, and the solution then tried with the current from two Daniell cells. A brass cathode being immersed, this was soon coated with a film of a brown colour, which was next succeeded by a similar play of colours to that noticed in the foregoing experiment, but after a time the deposit assumed a metallic aspect, and a fairly good film of a blue-grey colour was obtained. It was constantly observed during the entire series of these experiments that the colour of the deposit, even when the metal was of a strictly reguline character, varied considerably, from a colour nearly as white as cobalt to that of a very dark iron-grey. A further addition of acetate of ammonia was next given to the bath in the hope of improving the colour of the deposit, when it was found that while the metal deposited somewhat quicker after the addition of the ammonia salt, the character of the film was also greatly improved, provided the plate was left undisturbed in the bath. If, however, the plate

* *Jour. für Prakt. Chem.*, xxxiv., p. 381, and Brande's "Manual of Chemistry, vol. i., p. 877 (1848).

was removed from the bath after a few seconds' immersion, it first assumed a brown colour, quickly changing to pink, then to a dark blue, but on re-immersing the plate it soon received a bright deposit of antimony of a good colour, which retained its brightness during a long immersion. A steel plate, in the same solution, became coated with a bright film of antimony perfectly free from the colourations which had been noticed on the brass surface. The metal adhered very firmly to the steel.

30. *Chlorides of Antimony and Potassium.*—A bath was prepared by adding to a moderately strong solution of chloride of potassium one of protochloride of antimony prepared by electrolysis, as before described, and the resulting solution was then electrolysed with the current from two Daniells, when a prompt deposit of antimony of a steel-grey colour was obtained, which adhered firmly to the brass surface. Although the film was somewhat darker in tone than some of those previously noted, a fairly good depositing bath might be prepared from the salts named.

31. *Citrates of Antimony and Ammonium.*—To form an electrolyte a moderately strong solution of citrate of ammonia was added to a solution of citrate of antimony obtained electrolytically, as described in experiment 8, the resulting solution being then tried with the current from two cells, under which conditions a clean plate of brass received a deposit of antimony of good colour soon after immersion. There was a rather brisk evolution of hydrogen at the negative electrode, but the metallic deposit, however, adhered well to the brass surface.

32. *Oxychloride of Antimony in Caustic Soda.*—To a hot and strong solution of caustic soda was added, a little at a time, moist oxychloride of antimony, and the mixture boiled for a few minutes. The undissolved oxide was then allowed to subside, and the clear liquor afterwards poured off, and when cold electrolysed with the current from two cells. There was a brisk evolution of hydrogen, and the metal deposited very slowly; a third cell was then connected, and the solution moderately diluted, when deposition became somewhat quicker; the solution, however, was a bad conductor and failed to yield satisfactory results.

33. *Sulphocyanide of Antimony.*—A bath was formed by adding a strong solution of protochloride of antimony to one of sulphocyanide of potassium, when an orange-coloured precipitate at first formed, which quickly redissolved, producing a reddish solution, which, however, soon became colourless. The bath thus prepared was now tried with the current from two Daniells, but as the deposition was slow, a third cell was connected in series, when a deposit of antimony quickly formed upon a brass plate, the upper portion of which, at the water-line, was of a fine blue colour. On examining the film, however, it was found to adhere but very partially to the brass surface, which was probably owing to the rapidity with which the film formed when the plate was first put into the bath.

34. *Protochloride of Antimony in Phosphate of Soda.*—A solution of common phosphate of soda was first prepared, to which was gradually added a strong solution of protochloride of antimony, when the white precipitate at first formed became nearly all dissolved. After allowing the undissolved precipitate to subside, the clear liquor was poured off and electrolysed with the current from three cells, when a clean brass plate soon received a film of antimony of good colour, which was found to adhere very well.

Deposition of Antimony by Simple Immersion.—Many of the solutions described in the foregoing experiments were afterwards brought in contact with perfectly clean plates of brass, copper, steel, and zinc respectively, the object being chiefly to ascertain to what extent these solutions could be employed for imparting metallic or other stains to the surface of the metals named, with a view to their application for decorative purposes to certain parts of art metal work, and also for producing various coloured effects upon small articles of brass and other metals. It may be remembered that in former papers on the electrolysis of solutions of metallic salts, I called attention to certain solutions which could be employed in the way indicated, and also pointed out a method by which brasswork more especially could be rendered highly ornamental by coating certain parts of an object with electrolytic copper, to be afterwards stained in parts with a solution of an alkaline sulphide, while other portions of the coppered surfaces could be protected from oxidation, and left as copper, by a film of colourless lacquer. With respect to coppering portions of brasswork, as a contrast to the rest of the work, I have been pleased to notice that the suggestion has been adopted by some of our manufacturers, many specimens of brasswork thus ornamented being now visible in the shop-windows and warerooms. Moreover, this appears to have given rise to a kindred improvement in ornamental brasswork, in which metallic copper is tastefully blended with the brass, with which it forms a pleasing contrast of colour. During a recent visit to the Art Metal Exhibition, held at the Armourers' Hall, Coleman-street, London, I observed some good specimens of work of this class, though it must be admitted that some of the exhibits were scarcely as well finished as could be desired.

In the following table will be found notes of the effects produced upon the metals indicated when brought in contact with solutions of antimony salts, and in those cases in which a warm solution has been employed the fact is noted; in other instances cold solutions produced the desired effect.

Names of salts.	On brass.	On copper.	On steel.	On zinc.
Acetate and sulphate...	Metallic stain (warm solution)	Slight stain	Metallic stain	Grey metallic stain
Protochloride............	Violet metallic stain (warm)	Dark stain (warm)	Dark metallic stain	Same (warm)
Chlorides of antimony and ammonium	Slight stain (warm)	—	—	Metallic stain (warm)
Sulphate............	Dark stain (warm)	—	Dark metallic stain (warm)	Grey metallic stain
Nitrate	Black metallic stain (warm)	—	Black metallic stain	Same
Bitartrate	Black metallic stain (warm)	—	Black metallic stain	—
Sulphide in caustic potash	Dark br'wn stain	Slight metallic stain	Brown metallic stain (warm)	Brown metallic stain (warm)
Terchloride	Slight violet stain (warm)	Slight violet stain (warm)	Dark metallic stain (warm)	Grey metallic stain
Tartrate	—	—	—	Black metallic stain
Tartrates of antimony and sodium	Very slight stain (warm)	Very slight stain (warm)	Slight stain (warm)	Dark metallic stain
Chlorides of antimony and ammonium by electrolysis	Pink stain (warm)	Pink stain (warm)	Slight metallic stain	Grey metallic stain
Acetate	—	—	Metallic stain (warm)	Metallic stain
Acetates of antimony and ammonium	Metallic stain (warm)	Metallic stain (warm)	Pinkish metallic stain (warm)	Dark grey stain
Chlorides of antimony and potassium	Violet metallic stain (warm)	Violet metallic stain (warm)	Dark metallic stain	Grey metallic stain
Oxychloride in caustic soda	—	Slight stain (warm)	Grey metallic stain (warm)	Dark metallic stain (warm)
Citrate of antimony and ammonium	Slight metallic ring (warm)	Slight metallic ring (warm)	Metallic stain (warm)	Brown metallic stain
Sulphocyanide	Iridescent stain (warm)	Iridescent stain (warm)	Dark stain (warm)	Metallic stain
Protochloride in phosphate of soda	Metallic stain, pink and blue (warm)	Blue metallic stain (warm)	Grey metallic stain (warm)	Black metallic stain

It will be observed on glancing at the above table that the action of the respective solutions upon the various metallic surfaces was in most cases effected by warming the liquid. In fact, with the exception of zinc, which has a powerful reducing action upon most metallic solutions, there was but little disposition for the metal to deposit by simple immersion, unless the temperature of the solution was raised to from 130deg. F. to the boiling point. In some cases the reduction of the metal was very prompt.

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EXHIBITION JURORS.

It seems that the recommendation of the Electric Trades Section that there should be no awards in the electrical section at the Edinburgh Exhibition will be carried out after all, though this will be in spite of the determination of the executive council that awards should be given. Their determination has come too late or has been communicated too late for the jury to be constituted, and at the meeting of the London Chamber of Commerce on Wednesday it was decided to inform the authorities of the Edinburgh Exhibition that the meeting regretted their determination had not been submitted in time to be discussed earlier, before the meeting of the Institution of Electrical Engineers when at Edinburgh, and that the section could not now, as their members were all dispersed, see their way to nominate a jury.

The subject of jury awards at exhibitions, at one time expected as a matter of course by the exhibitors, has lately through two effects—the multiplicity of exhibitions and the difficulty of getting capable and efficient jurymen—become quite a debateable question. It is asked whether the prizes were worth receiving at all, or whether certain well-established firms were not risking a good reputation for quite inadequate gain. The recent disclosures of the underhand dealing which had been found to be present at certain exhibition awards could not be but a powerful factor in the consideration of the worth or worthlessness of such awards, and the recommendation of the Electric Trades Section when consulted upon the subject was that, in their opinion, there should be no awards at all; but that if it was decided that there should be tests of the various electrical machinery, that the section, along with the Institution of Electrical Engineers, should appoint the members of the jury. The executive council of the exhibition in reply to this declared that they agreed to this opinion, thus leaving the question open. We believe that the fact was the executive agreed to the prospect of no awards, and intended to so decide. But it was found that some exhibitors, more especially those of the foreign sections, practically refused to exhibit without the inducement of medals offered—their actual trade would not much increase, the *réclame* achieved was the only inducement. So it was decided finally to give awards. A week or two ago a letter was sent from the executive stating this decision, and asking for the promise for the appointment of jurors to be carried out; power and all appliances for testing would be provided, but the jurors would be expected to pay their own incidental expenses. The appointment was asked of three jurors by the Electrical Trades Section, and the same number has been asked from the Institutions of Electrical, Mechanical, Civil, and Naval Engineers.

This letter was only able to be discussed on Wednesday. It was felt that the application was now altogether too late; members had made their arrangements for the holidays, and could not be called upon to go to Edinburgh. It was mentioned that the Institution of Electrical Engineers and the Institution of Mechanical Engineers had felt it necessary to refuse, and the Electric Trades Section therefore did likewise.

We are afraid the decision will not prove very acceptable to the exhibition authorities, and to many of the exhibitors who have been preparing for the reception of awards. The exhibition has, owing to the great energy of its organisers, earned for itself the character of a thoroughly good and comprehensive electrical exhibition, and awards from such an exhibition by a jury constituted as was proposed could not fail to carry weight, and possibly be of great service to certain manufacturers. This being the case, if the careful decision of the executive council was that awards were to be given, it is a pity that the care and forethought that they have displayed in the exhibition itself did not extend to the matter of jury; for it would have been evidently only the question of a few more days for electrical members when at Edinburgh to stay and superintend the testing which was desired. The principle so much desired of the appointment of jurors, from sources which would carry the greatest technical weight, has, however, thus been even additionally affirmed by their non-appointment, and we suppose that the present precedent of the constitution of technical juries will be carried out at all future occasions.

THE LIGHTING OF LONDON.

"When are we to have the electric light at our doors?" has been the continual demand of the unbeliever. Well, if the light is tardy at arriving at the doors of dwellers of Brixton, of Hackney or St. John's, it is no more than might be expected, for "unto those that have more shall be given." It is to Kensington we must look. At your doors, Kensingtonians, the light is now laid on. You have but to send a note, give your houses into the hands of the contractor for a brief day or two, and afterwards pay your bills regularly, and you have your demand. In other words, the station of the Kensington and Knightsbridge Electric Company is now complete in all details—engines, dynamos, and storage cells—for a supply of 60,000 10-candle lamps, and its mains stretch in branching channels throughout the streets. Lamps to the extent of 100,000 may now be put on, and it wants but the addition of another engine or two, for which the room is ready as the demand increases. On Friday last, at the end of the season, Mr. Crompton issued an invitation to the inhabitants of his district, extending throughout that wealthy and fashionable district alongside Kensington Gardens, and stretching almost from Buckingham Palace down to Chelsea, where his wires now are laid, to an inspection of the station in its finished condition. By finished, we mean complete in building and in all arrangements, and in full working order; but, as we have said, there is still space to erect other machines. The dynamos at present consist of four of 200 h.p. and three of 90 h.p., and the batteries of huge storage cells are capable in case of need of giving a current of 1,200 amperes at 110 volts. It is found well to keep them in active operation, and often in the evening only one dynamo is kept going, the bulk of the current being supplied from the batteries. The handsome red brick building, the neat apparatus for switching and supervision, the clean and airy appearance of the station, lend an air of thorough arrangement and control; while the knowledge of the stored supply of current and its low voltage is one of great satisfaction to the average householder. The Kensington station is one which every electrical engineer ought to see.

RAILWAY RATES.

The important matter of railway rates for electric plant has now, thanks to the energetic action of the London Chamber of Commerce, received the attention it deserves. It will be seen from the new amended rates, which we give elsewhere, that dynamos, accumulator plates, electric cable and wire will take position under classes to which they belong. There are still some points which might be advantageously altered, but on the whole the electric trades have come out very well in the rearrangement of rates. The manner in which the subject has been discussed and carried out is this: The railway companies were asked by the Board of Trade, pursuant to the Act of Parliament, to state their proposals as to the fresh rating of the goods traffic; the various trades sections of the London Chamber of Commerce were to do likewise. The various sections appealed to their members for their experience and ideas, and this information, under the efficient superintendence of Mr. Musgrave, the assistant secretary to the Chamber, and his staff, after daily and nightly work, were cast into shape. The Board of Trade then asked the Chamber to first negotiate with the railway companies direct. This negotiation resulted in certain modified proposals by the railways, and it is upon these modified rates, and the suggestions of the Chamber of Commerce, that the Board of Trade have reported. This decision, or report, will come before the Select Committee, any further necessary alterations will be made, and the rates will then become law.

CORRESPONDENCE.

THE LINEFF TRAMWAY SYSTEM.

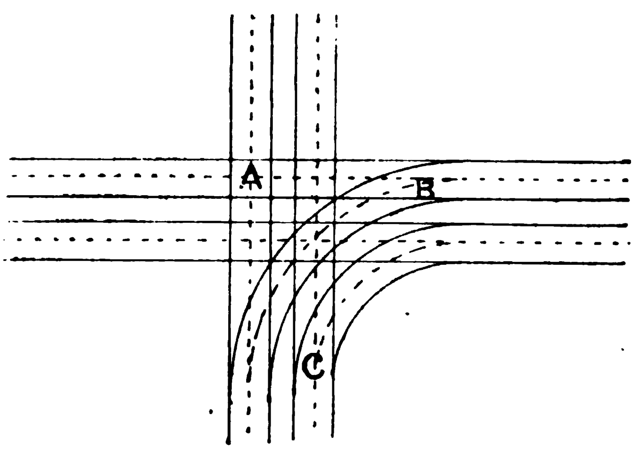
To the Editor of the Electrical Engineer.

Sir,—To misunderstand is one thing and is pardonable, but to persistently and deliberately misrepresent is quite another, and the only excuse I can find for Mr. Lineff is the disappointment he must naturally feel in learning that what he honestly thought originated in himself had been anticipated.

I do not think that anyone else but Mr. Lineff will suppose that by a continuous articulated conductor I meant 600 distinct switches per mile. My last letter was sufficiently definite to leave no excuse for such a statement.

For the system itself, surely Mr. Lineff must see that the "snake" overcomes the subsidiary wave theory that has been pointed out as possible by others, and unless Mr. Lineff's experience differs from mine he will find really exists when a flat strip is used. Assume you are at the terminus of a line, and four or five cars are waiting to start and they all pick up at the same time, what becomes of the flat strip? If that strip has really lain flat before the cars were there, and the four cars whilst close together try to pick up, forming four waves in four car lengths, and move those four waves along as they proceed, what happens? The conclusion I arrived at as the result of my experiments with the flat strip is that the waves either will not all be made or they will not all be unmade; one or more will be left touching the upper surface, leaving a positive danger to the public. The contact maker must, therefore, be articulated, or it must not be continuous. It occurred to me that it might be expedient to use sectional strips, each, say, of two car lengths, but seeing the possibility of the separate lengths of strip being gradually worked forward by the wave action and overlapping one another, I designed a simple method of keeping them in position.

I have read with interest the appendix to Mr. Kapp's report, and thoroughly endorse his opinion that it will be necessary to adopt some means for keeping the closed channel dry. I went into the matter in the early part of 1887, and found the addition to the capital outlay was not slight; perhaps my details were unnecessarily complete. An initial insulation of only 186 ohms per mile is too low. Remember that this is obtained by calculation from a short sample length constructed presumably with the greatest care. To have a few miles of line laid without a flaw is more than can be reasonably expected. I venture to predict that unless some system of drying be adopted, or the closed channel be made more like my own, the insulation will not be more than 100 ohms per mile. Now for two miles of street with double line this would only give 25 ohms as the total insulation, without adding the surface leakage when the cars are running.



Measurements taken on the short sample line cannot be accepted as what would occur in practice, where points and crossings have to be encountered. Take the accompanying sketch as illustrating what frequently occurs, and assuming that the by no means easy problem of maintaining means of communication with the enclosed conductor and avoiding short-circuit with the intersecting rails is overcome, what will be the surface leakage on a wet day with cars in the positions indicated by the letters A, B, C when the charged region behind each car extends as far as 8ft. 6in.?

I confess that I failed to make my flat strips wave round curves, hence my reason for preferring the "snake." I also confess that if my system left 8ft. 6in. of live contact rail behind the car I should hesitate to deal with the conditions shown in this sketch.

There is a point not yet touched upon in any notices I have seen on this system—viz., assuming the maximum current to be passing to a motor on a car, and that from some accident the collector magnet ceases to be energised, releasing the "strip," it won't drop suddenly nor will it altogether subside; the wave crest will simply be depressed, leaving the magnet surface bar above it, and so breaking circuit at this point. I leave those who have had experience in switching off big currents to say what would happen inside the closed channel. As there is no facility for examination, this becomes a most serious matter.

Taking the points mentioned and others into consideration, it seemed to me that the system was only applicable to country places, where it is to be hoped English authorities will before long permit overhead conductors, and as tramway companies are still expecting commercial success with batteries, I have had no opportunity of testing its merits beyond my sample line. The system, therefore, has from necessity as well as from choice become historic.—Yours, etc., M. Holroyd Smith.

Halifax, August 5, 1890.

ELECTROLYTIC THEORIES.*

BY PROF. G. F. FITZGERALD, F.R.S.

Electrolysis has been explained on two different theories by Grotthüs and Clausius. As generally received they differ. Grotthüs's theory, as generally given, assumes that the molecules in an electrolyte are both polarised and moved by the electric forces within the liquid. This seems so far untenable that it would appear that double the electric force would double both the polarisation and the motion of the molecules, and so should produce four times the electrolysis. The objection, however, assumes that we know the causes resisting the motion, and with proper and not very improbable assumptions as to the resistance to motion depending on it and on the polarisation, a linear relation between current and E.M.F.—*i.e.*, obedience to Ohm's law—seems possible. A modification of Grotthüs's hypothesis in the direction of Clausius's is, however, possible. Suppose that when polarised the molecules *drew one another apart* at a rate proportional to the polarisatiou. This at once makes the relation between electric force and the decomposition a linear one, and so satisfies Ohm's law in the case of small currents. It also so far agrees with Clausius's hypothesis that it explains electrolysis and double decomposition as properties of the same kind. The molecules in a liquid will occasionally be arranged by accident in the proper polarised condition in a closed circuit for drawing one another apart; and if the circuit includes molecules of different kinds, there will result double decomposition. There seem to be very serious difficulties in supposing that uncombined atoms are for any finite time free in the liquid; and the supposition that it is a particular arrangement that is required before exchanges take place, and that with this arrangement exchanges take place of their own accord, seems to explain electrolysis and double decomposition without supposing free atoms to exist within the liquid. I have not assumed Prof. Armstrong's suggestion that the proper arrangement for double decomposition is a double molecule; but it seems a likely hypothesis, and one that should be investigated from the chemical rather than the physical side.

There are some other phenomena that have been explained upon the supposition that free atoms are gadding about in a liquid. Such are the lowering of the boiling and freezing

* Communicated by the Secretaries of the Electrolysis Committee of the British Association.

tion between them, so that the metals constituted a voltaic couple, the negative current from which appeared on the iron. The positive current on the copper was consequently due to the copper wire acting with the iron bolts of its own insulators, the iron bolts of the neighbouring insulators, and the iron wire which they supported. The negative current on the iron was due to the iron wire, its bolts and the bolts of the neighbouring insulators acting with the copper wire. But the bolts of the insulators, Fig. IV., were partially earthed by the damp wood of the poles and the earth wires which ran down them. If the earth had been perfect no current could have got to the galvanometer, but since it was only partial some found its way by that route, and so the difference in strength between the positive and negative currents is accounted for. The positive, depending chiefly on the action between the copper wire and its own bolts, between which no earth intervenes, is necessarily stronger than the negative, which depends wholly on the action

FIG 1

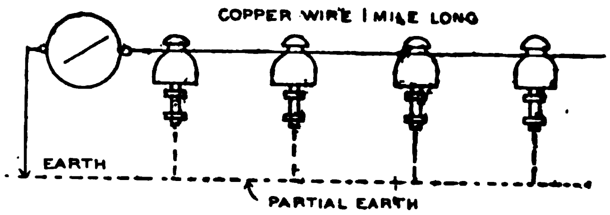
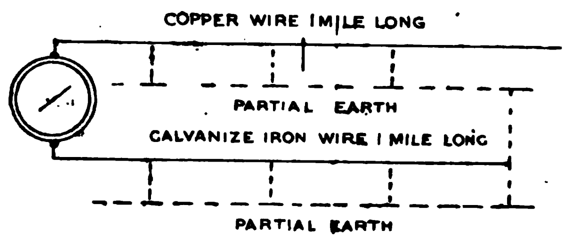
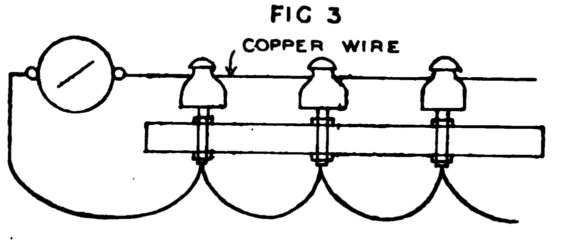


FIG 2



FIC 3

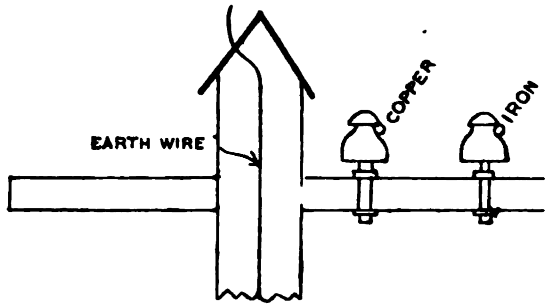


between the iron wire and bolts and the copper wire, between which a partial earth is interposed, Fig. V. So when the earth is cut off from the galvanometer, Fig. II., the effect of the earth between the two plates is neutralised, and the positive and negative deflections become equal.

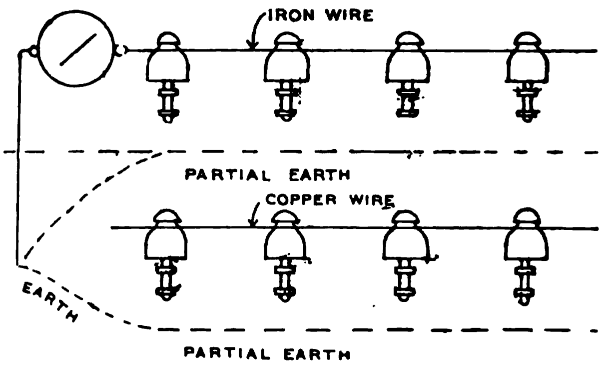
A somewhat unexpected effect of the recent introduction of copper wires for telegraph and telephone purposes is consequently the establishment over the country of a vast number of voltaic couples, which only become operative in damp or wet weather. The zinc of the bolts of insulators carrying copper and bronze wires may reasonably be expected to disappear sooner than in days gone by when only iron wire was used, and when copper and iron wires are run on the same poles the galvanising of the iron must suffer sooner than of yore. The Americans, with the wooden pins, will escape the currents due to the difference of metal between the wire and its supports; but when they mix wires of different metals on the same poles, the resulting action will be stronger than with us, since they do not earth-wire their posts.

Telephonically, the existence of these currents is of little moment. With metallic loops, when both wires are of the same metal, they will not matter at all, since the currents from two similar wires will be in the same direction and of the same strength, and, meeting in the telephone or translator, will neutralise one another. On single wires, so long as the currents remain steady, their presence does not matter much. As they increase gradually as the insulators become wet, and die away slowly as they dry, they do not give rise to any disturbance in the telephone. If any confirmation of the voltaic origin of these currents were needed, it would be afforded in the fact that it is possible, by charging the line from a battery, to polarise the line couple even to the extent of obtaining temporary currents of the opposite sign. Thus, the copper was repeatedly charged from a 90-volt battery: when from the positive pole the line current was increased, when from the negative the line current was decreased and sometimes reversed.

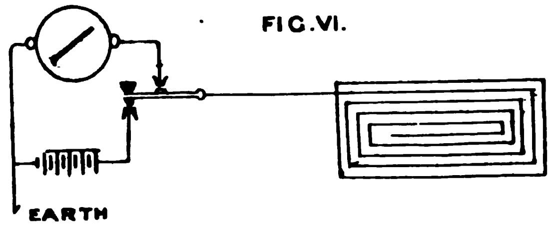
FIG 4



FIC V



FIC.VI.



The following are particulars of several tests of the copper wire, the deflections being in degrees:

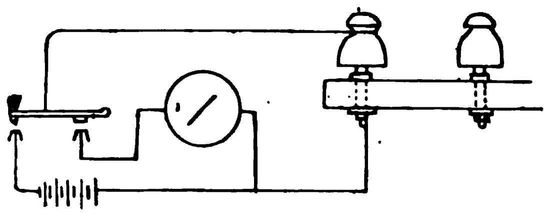
Charging wire from 90 volts—to line so as to neutralise and overcome line current.

Line current.	Duration of charge.	Result.
·5+	10 seconds	Reversed to ·2 –
6+	20 seconds	Reduced to 5+
8·4+	4 minutes	Reduced to 3·5+
12·5+	10 seconds	Reversed to ·2 – Spot went back instantly to 5+, and then recovered slowly to 12·5+.
12·5+	20 seconds	Reversed to ·4 – Went back quickly at first and then slowly recovered to 12·5+ in 45 seconds.
12·5+	1 minute	Reversed to ·8 – Went back instantly to 3·5+, recovering slowly to 12·5 in 70 seconds.
12·5+	2 minutes	Same as 1 minute
12·5+	3 minutes	Same as 1 minute

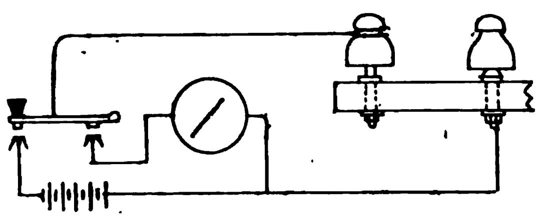
The same effects were produced with the experimental arm. With only one insulator reversed, the cup being full of water and the surface well wetted, a deflection was got of 4deg., equal to ·0027 milliampere. When the current from this insulator was reduced to ·2+ through the surface drying, a reversal could always be obtained to ·4 –, and sometimes to ·6 – by charging it from 90 volts.

During the capacity tests already mentioned it was observed that for some time after the commencement of rain the apparent capacity of the wire invariably rose instead of falling with the decrease of insulation. This effect has, of course, been noticed before, but as the author was not aware that it had been satisfactorily accounted for it was resolved to investigate, and the result of the investigation seems to point to several contributory causes. Firstly, no doubt, the line current due to the voltaic action already described will increase or diminish the discharge according to the direction of the charging current. Secondly, the polarisation of the bolts due to the charging current will have the same tendency. But the capacity of the line will appear too high when the moisture on the insulators is too slight to permit of voltaic action. To seek the cause of this, 12ft. of copper wire was run on six dry insulators fixed in oaken arms in the test-room. With 90

FIG VII.

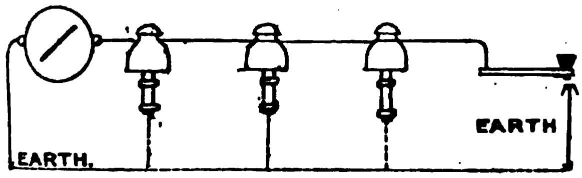


A



B

FIG.VIII.



volts the wire gave a discharge of ·4deg. The tops of the insulators around the binding wire were wiped with a wet sponge; the discharge then rose to 1deg. more than double. Wetting more of the surface of the insulators resulted in a still further increase; several discharges could be got without renewing the battery charge. It would therefore appear that wetting the insulators is equivalent to an increase of conductor surface. The moisture has to be charged as well as the wire, and the consequent discharge is greater than with a dry wire. The effect is only observable in moderate rain, or for some little time after the commencement of heavy rain; when the insulators become thoroughly wet the insulation and the capacity fall together, and then the voltaic action and polarisation come into play together with another phenomenon which has not yet been referred to.

Incidentally, in the course of these tests, it was found that when a wire was in contact with moist wood and is charged from a powerful battery (90 volts were used) the discharge is several times stronger than when the same wire is supported on dry or partially moist insulators. Thus a length of wire on insulators gave a discharge of ·9deg. when stapled along an oaken arm not sensibly damp, the discharge after 20 seconds charge amounted to 4·5deg., and after 80 seconds to 5deg. Then a residual charge appeared to remain in the wood, as the wire continued to yield a current of ·5deg. for some minutes, then gradually dying away to nothing. Many tests, varied in details, gave the same results; 30ft. of wire in air gave a discharge of ·4deg. When the same wire was stapled on a deal board, Fig. VI., not sensibly damp, with staples of the same metal as the wire, the discharge became 3·5deg., falling immediately to 1deg., and then slowly to zero. The wire and the wood were then sponged, and the discharge rose to 7deg., falling immediately to 2deg., and returning slowly to zero. The wire yielded a series of smaller discharges for several minutes without any fresh contact with the battery. A deal box wetted, having some bronze wire in contact with it, was well insulated by being suspended by guttapercha. Charged for 20 seconds from 90 volts, it gave a discharge of 1·6deg., sinking immediately to ·8deg., and then gradually to zero. The same box standing on the floor gave a discharge under the same conditions of 12deg., sinking to 3deg., and then slowly to zero. The same box touched by the end of an earth wire, also of bronze, well away from the bronze wire, gave a discharge of 45deg., sinking immediately to 26deg., and thereafter slowly to zero. In the two first cases only one metallic conductor, that is to say, the bronze, through which the charge was communicated, was present, and the source of the return current is not very apparent.

The last case closely resembles a wet telegraph pole, the earth wire of which does not touch the bolts. Then an expanse of wet wood intervenes between the bolts and the earth, and a powerful charging current in the line must, with leaky insulators, result in back currents. As it is evident that moisture in wood has the effect of increasing the capacity, it may not be unreasonable to deduce that moisture in the air surrounding the wire may have the same effect. The foregoing particulars apply whether the line is of copper or of iron. The following observation applies to iron alone:

It has been mentioned that no current between a galvanised iron wire on a wet insulator and the bolt could be detected. But if such a wire is charged by 90 volts, the discharge is followed by a counter current from the insulator. The effect can be produced with a few inches of galvanised iron wire and a wet insulator, as in A, Fig. VII. Charging such an arrangement by 90 volts yielded a discharge of ·4deg. and a counter current of ·3deg., which did not wholly disappear for some three minutes. Obviously, the polarisation of the bolt following on electrolysis of the moisture made the insulator a secondary battery. The effect of damp wood may be markedly shown by shifting the return wire to the bolt of an adjoining insulator, as in B, Fig. VII. The discharge then became 1·5deg., and the counter current 1deg., an augmentation of nearly four times. Connecting the earth wire direct to the bolts will obviate the effect of moist wood, but it increases the strength of the voltaic action and the polarisation of bolts by the charging current.

Although the Americans escape the voltaic action consequent on the use of metallic bolts, the damp wood of their poles cannot be without its effect in wet weather with the insulators they use. The current set up between copper wire and iron bolts in wet weather might be used to signal with. The experiment has not been tried, but it seems plain that a galvanometer at A, Fig. VIII., through which the line current circulates in its full strength when the wire is insulated at B, would be affected by the working of a key between the line and earth at B, for the key when closed would shunt a large proportion of the current away from galvanometer.

It will be observed that these experiments were made with the distant ends insulated, a condition which does not obtain in ordinary telegraphy. The practical effect of the disturbances noted may be insignificant, especially with double-current working, but still it is well to know that they exist.

NOTE.—Since reading the paper it has occurred to the author that the probability of this conclusion* is strengthened by considering that dry and moist air have very different capacities for heat. Tyndall found that the

* That arrived at in paragraph beginning 'The last case clear y resembles."

absorption of heat by dry air being 1, that of the air of his laboratory, not specially damp, was 72, while that of air designedly moistened was no less than 90. Thermal and electrical vibrations differ only in frequency, so some common absorptive action in respect to air may be looked for.

The heat absorbed by the moisture in the air is, after the withdrawal of the source of heat, radiated or discharged, not instantly but gradually, just as the electrical charge, after the cutting off of the battery, is parted with slowly and by degrees, as indicated by the residual charge. It may be expected, therefore, that the apparent capacity of a conductor will be least when contained in artificially dried air.

HOW TO ESTABLISH A CENTRAL ELECTRIC LIGHTING STATION.

BY SYDNEY F. WALKER.

In the following the writer proposes to discuss the question of how best to proceed in establishing electric lighting, say, in a town, with a view to the great desideratum in all industrial undertakings—viz., ensuring an adequate return for the use of the money invested. For it must not be forgotten, however ignoble it may seem, that success or failure will ultimately be awarded to the enterprise solely on the ground of whether it earns a good dividend or not. Even philanthropic shareholders, who profess that they invest their savings for the sole purpose of helping on the great inventions of the age, are just as keen on the matter of dividends as their more worldly-minded contemporaries, because, don't you know, so much more good can be done with the money if the accruing interest is added to the principal.

Next to earning his dividend, or rather as a means towards earning it, the engineer or manager should put before himself the condition that he must have absolutely no failures. Nothing will spoil his chances of earning a dividend more than failure of his lights, because it will lose business, and will put his company to considerable expense in addition. Gas is not to be compared to the electric light for almost every quality that tends to sweeten life, yet much as the British householder would like the electric light, and heavily as in very many cases he will be prepared to pay for it, he will not have it at all, and he will not pay for it if there is any chance of its leaving him in the dark.

Therefore, so far as it is possible, all means must be taken to minimise the possibility of breakdowns.

Next, also a factor in the matter of dividend-earning, keep the capital account as low as possible consistent with maintaining a service free from breakdowns. If, for instance, £10,000 will establish a station upon which a net income of £500 per annum can be earned, though this is not an extravagant profit, shareholders will not grumble if it is maintained pretty constantly year after year, and with care there would be a very good chance of the dividend being increased as the years rolled on. But if, through wasteful or expensive management, the amount required to be sunk was £15,000 or £20,000, while the net earnings were the same—£500 a year, or possibly less—shareholders would grumble very considerably indeed, and with justice. The engineer must, however, be very careful not to make the mistake of saving a few hundreds or a thousand or so, taking the same capital figures, and thereby endangering the constancy of his service. Suppose, for instance, that by neglecting to duplicate some portion of the apparatus that may break down a saving of £1,000 is effected. Suppose the engineer says, as some do, "I don't believe in duplicating machinery; it only makes men careless; my men must look after their apparatus properly, and there will be no breakdowns." And suppose that one of those accidents occur that in electrical work—in all new work, at any rate—scarcely any foresight appear to be able to guard against, because they are new experiences, and a breakdown does occur, and that the cost of this breakdown, including loss of business, sops to consumers, etc., is £100. How will the dividend stand then? The capital account is £9,000, the dividend £400—not quite 4½ per cent. instead of 5 per cent.—and with the certainty that the £1,000 must now be expended, if not more.

Next, as to the choice of a site for the station. Many considerations must be taken note of in this matter. The station should be in as central a position as possible, in order that the mains, radiating in all directions, may be of as small a section as possible. But, as is well known, central positions are always the most valuable to rent or to buy. In fact, the difference between the rent of a station in the centre of a large town and of one in the outskirts would often amount to an appreciable percentage on the capital employed. Taking, for instance, the same capital, £10,000—which is equivalent to a plant for from 4,000 to 5,000 16-c.p. lamps. If the station could be well out in the suburbs on a piece of waste ground, £50 a year would be a high rent to pay, unless a dwelling-house suitable for the resident engineer was included. In the centre of the town £250 a year would be by no means exorbitant. The difference between the two, £200, would pay a dividend of 2 per cent. on the £10,000. Added to this is the remarkable fact that gas works are invariably placed in the suburbs, though their mains are subject to much the same rules of supply that ours are.

Another point to be considered is the supply of coal and water for the boiler. This may seem a simple matter, and one that can be left to take care of itself, but in reality it is not so. The difference in cost of running, for instance, between taking water from the town supply and from, say, a river, may again have an appreciable effect on the dividend. Towns water is always dear, even for domestic purposes, and it is, perhaps, not exaggerating to say that dearness of supply is one of the principal causes why small water motors are not more used in small industries.

There is also another consideration in the matter of water—viz., its action upon the boiler. As is well known, not only sea water, but some spring water has a very serious effect upon the life of the boiler, unless it be very carefully looked after and protected from the galvanic action that takes place. When heated, while steam is being generated, different portions of the boiler are in different states electrically, there being actually an E.M.F. existing between the part directly exposed to the fire and the cooler portion above; and it will be evident that the more the water in the boiler is impregnated with metallic salts, up to a certain point, the lower will be its resistance, the stronger will be the current passing, and the greater the action upon the shell and tubes. Therefore, in certain cases, it might even be cheaper in the end to use the expensive towns water than a natural supply, such as that taken from a river or canal.

Then as to coal. This and water are really the food of the station. If either fail for long, the electric light service must cease. There are two points to be considered here too—viz., the quality of the coal and its delivery at the works. For the latter almost the ideal spot would appear to be, when it can be obtained, the banks of a canal which is in communication with collieries producing steam coal. Where that cannot be there should be easy access by a siding if possible, if not by a back lane, and as much room for storage as can be arranged. The matter of quality will be dealt with later on.

Then, further, in choosing a site for the central station it will be well, as far as possible, to choose one that allows of easy access to the principal points of consumption, both overhead, if the supply is to be taken that way for a time, and underground. For the latter it is evident that only the line of the streets can be used, so that wherever the station is, the real point of departure for the mains must be where they first emerge upon a main thoroughfare. For this reason, though it might be possible to obtain premises away from the main thoroughfares at less rental than would be required in a main road, it might not be advantageous in the end to take them, owing to the additional cost of leading the mains out, and the almost certain additional cost of maintenance of them, besides the possibility of such charges as for making good foundations, damage to party walls, etc.

It may be possible in some cases to start the station in a back court, and when it has grown sufficiently to remove it to the outskirts. In this case the cables may be run over-

managers, 133s.; horse feed, 15s.; timber, 20s.; coal, 55s. The total cost per ton comes to 30s. 3d., made up as follows: Breaking, 9s.; tools, 4d.; fuse and dynamite, 2s. 3d.; timber, 4s.; trucking, 8d.; carting, 1s. 3d.; crushing, 8s. 8d.; light, 2d.; management, 2s. 2d.; interest on paid-up capital, 1s. 9d. No separate account being kept of proportion of timber, tools, dynamite, and management for prospecting, pumping, and general up keep, this return does not give a basis to work from. The cost per ton would evidently greatly lessen if the output was increased. The cost for management, crushing, interest on capital, etc., would be but slightly increased if three times the quantity, which is 248 tons per month, were dealt with. It is in this direction we must look if our reefs are to become of value to shareholders. One pound a ton profit is not of any value when only 200 tons are crushed for a season's work. Let the mine crush 5,000 tons per year regularly and it becomes what its name implies, a veritable gold mine. In a reef 3ft. wide, 62ft. must be driven out per week to supply this amount, and four stopes or headings kept continuously at work. This in ordinarily hard ground means 24 miners, three truckers, three breaksmen, 12 men opening out or sinking on new ground, with as many more for battery and other purposes. The outgo would be £800 per month, with the average return of £2. 12s. 6d. £13,125 would be got and dividend of 35 per cent. earned on £10,000, the capital probably required.

At Nenthorn the average width of the reefs is much less than 3ft., but the returns show over 1½oz. to the ton. At the head of Lake Wakatipu the average is 5dwt., but the width is from 4ft. to 14ft. In both cases, only by greatly increasing the output can the claims become of any value to shareholders. While at Macetown a note was taken of the cost of getting out 100 tons of stone. Day labour was employed, and the best of miners, who worked as only miners can work when on the job. The wages came to £31; steel, 4s.; coal, 25s.; timber, 43s.; powder and fuse, £3. 6s.; incidentals, £2. 7s., equal to 8s. per ton.

With the mines opened out and overhead stopping adopted any required quantity of quartz can be gained at the same price by contract. The various companies only require a preliminary outlay of from £2,000 to £3,000 in opening out and erecting crushing plants at or near their tunnels. They should have only the best of ore-saving appliances, which will save not only the free gold but all the pyrites as well. Until it is recognised that quite 25 per cent. of the gold in our reefs is at present lost by amalgamation no permanent progress will be made in this direction. If the School of Mines would establish a works for the treatment of pyrites, and every reef save all their minerals in a concentrated form and send it for treatment to such an establishment, much good would be done alike to the pupils of the university, the mine owners, and the country. In one case known to the writer, 1oz. 16dwt. of gold per ton was saved by the battery process, and a report received from an analytical expert that 11oz. 8dwt. were lost per ton of pyrites. The quantity in the quartz was not known.

At Macetown, a district almost deserted as a quartz mining centre, an average of over 17dwt. has been given, yet there are only two mines at work. Were this district in Victoria there would be 20 mines in full operation, each employing over 50 hands, for, with the exception of Reefton, it is one of the cheapest places in New Zealand to carry on quartz mining, want of timber being the only drawback. This is, however, more than compensated for by no steam or pumping plants being necessary.

With electric power plant in the Twelve Mile or Arrow river every mine at Macetown, including the celebrated Tipperary, could have crushing, drilling, and light supplied directly at the point required, saving all cost of tramway or haulage, and also saving 33 per cent. of the present cost of driving entailed by the use of power drills. In hard ground by hand drilling, using 1in. steel, with three men—viz., two hammerers and one turner—the cost per foot of hole averages 3s., which includes cleaning and firing. A mine employing nine men all the year round in opening or prospecting new ground has to pay £1,012 for drilling alone. It may be considered a good average if 1·33ft. per man per week is driven, say, 600ft. per year for this number of men, and the cost comes out as follows: Dynamite and fuse, £270; rails and sleepers, £90; ventilation, £15; steel, coal, incidentals, £17. 10s.; wages, £1,350, equal to £2. 18s. per foot. An electric drill is now in use, weighing 100lb. It will bore the hardest anthracite or quartz rock at the rate of 30ft. per hour, at a cost of 2½d. for power. Using these drills, the cost for 600ft. of tunnel in hard country would probably not be more than £1. 19s. 6d. per foot, saving £600 and six months' time. Prospecting and driving new levels are in most cases dead work, and a saving of 33 per cent. is an item no mining company can afford to ignore, while to the workman it means much less laborious and more constant work. In the case of the Tipperary immediate and certain returns could be had with a very moderate expenditure—probably not more than £5,000—and a delay of two years' time could be avoided, and at least 1,000ft. more in depth could be worked from the present shaft site. The New All Nations, Garibaldi, Maryborough, and Homeward Bound mines are all known to be payable under favourable conditions; yet at present they are only held on sufferance, no capital being available to properly develop them.

As many of the reefs in this district carry large quantities of mineral a heavy percentage of gold has been undoubtedly lost, for every battery manager knows that this class of quartz makes the silver sicken much more quickly than when clean stone is crushed. By using sodium amalgam this is to a greater or less extent prevented, for the sodium decomposing water forms caustic soda, NaHO, and setting hydrogen free, the hydrogen in its nascent state has its power greatly increased, and seeks to combine with sulphur, oxygen, or arsenicum, to form compounds that are carried off by the water. By using an electrical current of low electromotive power the same effect is produced in a constant and regular manner without cost, beyond that for the power to drive the dynamo. The beneficial effects are amply demonstrated by Mr. E. S. Bennett's letter and my own experiments. When, however, sulphide of antimony occurs in any considerable proportion in the quartz this treatment is of no use, and would probably exaggerate the evil it is intended to cure, for it would help the silver to form an alloy with the antimony. Sulphuretted hydrogen would tarnish both gold and silver, and prevent their metallic contact, by which means amalgamation takes place.

It is impossible to save all the gold contained in pyrites by any process of grinding and amalgamation. Grinding has certainly the effect of cleansing a portion of the contained gold, but to save nearly all it is necessary to roast and decompose the sulphides entirely.

At Widnes, depositing dynamos have recently been supplied by Elwell-Parker to the extent of 1,000 h.p. for copper refining. The process is far cheaper than the ordinary method, costing only 10s. per ton. The oxides are cast into plates 2in. thick, which are used as anodes in a depositing bath of sulphate of copper, pure copper depositing, all impurities, together with all the precious metals, settling as sludge. Fifty-six tons of pure copper per week are deposited by these dynamos.

Dredging.

Of late a large amount of capital has been subscribed for the purpose of gold dredging, which has been forcibly brought to the front through having so dry a season; not one half the normal rainfall having been reached. The rivers having continued low and water for sluicing being consequently scarce, miners were forced to try the river beds, which in general are covered with tailings and water. On the Clutha, just above Cromwell at the Nevis, on the Kawarau, and on the Lower Shotover parties known to the writer got first-class returns by using the most primitive of appliances, and attention was drawn to the fact that a heavy account was paid by a party who were supposed to be idle for want of water to sluice with. They were found to be quietly working the ground left dry by the river, and were making £6 per week a man cradling. On prospecting, the river for some distance above and below them was proved to contain highly payable drift, and two claims were taken up, but nothing has been done to them.

The Sew Hoy dredge on Big Beach just at this point started to give fancy returns from old ground on the Shotover, and went to prove that with an expensive system (it costs £60 per week to work and maintain) of steam-dredging, ground hitherto thought useless became of great value. Claims were marked off from the Kawarau to the branches of the Shotover, down to Cromwell and to Rocky Point on the Clutha, and in many other places.

In many instances prospects were obtained that ensure the success of the companies now under way, and the first dredge started will more than astonish some who think lightly of gold-mining.

In one of the prospectuses issued by a company, now fully subscribed for, £3. 5s. per day is set down for coal, and the following facts were brought under notice at the time: They are one of six companies now proceeding with the erection of plant within a distance of three miles on either side of an ample water power. Six companies will use at least £5,000 worth of coal each year, and the cost for depreciation of steam plant comes to £720, while three engine-drivers at £3 per week for six dredges mount up to £2,700. This is without any lighting account per year. Should each dredge be worked fairly constantly the cost for steam plant and roads for this special purpose will be not less than £4,000, which at 8 per cent. is £320. This totals up to £8,740.

Let us see what this would cost by using electric power plant. Each dredge takes from 40 h.p to 60 h.p. Averaging, then, at 50 h.p., we have 300 h.p. to be supplied on board. £1,300 would give a first-class plant to each company from a central station, or a total of £7,800. Water power, wheels, houses, etc., with lines for each dredge, £500, or an additional £2,000, which brings the total up to £10,800. This, at 8 per cent. on the capital outlay, is £864. Wages—three men at £3 for central station, £450; two boys, £150; depreciation at 10 per cent. (which is found to be ample on electrical machinery), £1,080; electrical engineer, £350; or a grand total of, say, £484 per year as the cost of power for each dredge using electricity placed favourably for water power. Using steam, this item comes to £1,456, which means a clear saving to each company every year of £972. Presuming that each dredge complete costs £5,000, this means 19 per cent. saved on the total capital outlay.

The incidentals, such as oil, waste, etc., have not been taken into account, as they are common to both systems. Nor has the rental of water or profit, as in this case the right is owned by one of the companies, who would meet the others in a very liberal spirit, and this would not affect the general issue.

With a view to elicit the latest information on the subject from other companies in other parts of the world, application was made to Mr. E. S. Bennett, of New York, who has patent rights by which the gold-saving apparatus depends on electricity for its success, and the following letter has been placed at the disposal of your readers by consent, and will afford food for reflection to parties having beach claims where fine gold is the rule.

"Astor House, New York, June 19, 1889.

"C. W. J.—Dear Sir,—In response to your enquiry as to what can be accomplished by our machinery, I enclose card with tabulated statement of the capacity and cost of running on several styles of machines. At the upper left-hand corner of the card you will notice a specimen of fine gold. I have written your name at

Stockwell have been finished, and the buildings on the surface are in a forward state. The lifts and signalling arrangements are approaching completion. The engines for generating the hydraulic power and the boilers for working all the machinery are ready for starting. The electric working conductor has been fixed throughout; two of the three electric generating engines have been erected; delivery of the locomotives has commenced, and some of the carriages are ready for delivery.—I am, gentlemen, your obedient servant, J. H. GREATHEAD, M.Inst.C.E.

BALANCE-SHEET FOR HALF-YEAR ENDING 30TH JUNE, 1890.

				£	s.	d.	£	s.	d.
To share capital—									
Subscribed capital				507,500	0	0			
Amount received on shares issued							504,468	0	0
Debenture account—									
Amount created				150,000	0	0			
Amount received on debentures issued							149,700	0	0
Sundry creditors (exclusive of liabilities on purchases of property not completed)				4,538	0	4			
Contractors' retention fund account				21,751	16	0			
Amount advanced in respect of parliamentary deposit 1887 and 1890 Acts				17,001	18	0			
							43,291	14	4
							£697,459	14	4
By expenditure—				£	s.	d.	£	s.	d.
As per last account				559,242	9	1			
Expenditure during half-year	43,144	10	3						
Issue of capital	2,855	16	1						
				46,000	6	4			
							605,242	15	5
Administration expenses—									
Salaries, Directors' and Auditors' fees, law, and sundry expenses				1,481	8	10			
Less transfer fees	4	7	6						
,, interest	91	15	5						
				96	2	11			
							1,385	5	11
							606,628	1	4
Land and property—									
As per last account				53,665	5	11			
Additions during half-year	391	5	7						
Less rents received	137	0	0						
				254	5	7			
							53,919	11	6
Parliamentary deposit 1887 and 1890 Acts							17,001	18	0
Sundry debtors							4,750	14	1
Cash at bankers and in hand							15,159	9	5
							£697,459	14	4

CITY NOTES.

Direct Spanish Telegraph Company.—The receipts for July were £2,016, against £1,677.

Eastern Telegraph Company.—The receipts for July amounted to £54,224, against £54,248.

West Coast of America Telegraph Company.—The receipts for the month of July amounted to £5,825.

Brazilian Submarine Telegraph Company.—The receipts for the week ended August 1 amounted to £5,114.

Eastern Extension, Australasia, and China Company.—The receipts of this Company for July were £46,367, showing an increase of £3,491.

Cuba Submarine Telegraph Company.—The receipts for July were £3,150, as compared with £3,003. The receipts for April, estimated at £3,600, realised £3,624.

Great Northern Telegraph Company.—For July the receipts of this Company were £25,600, making, from January 1 to July 31, £156,000, against £154,200 in 1889, and £156,000 in 1888.

West India and Panama Telegraph Company.—The receipts for the half-month ended July 31 were £2,671, as compared with £2,672. The April receipts, estimated at £7,192, realised £7,233.

Western and Brazilian Telegraph Company, Limited.—The traffic receipts for the week ended August 1, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,921.

Western Counties Telephone Company.—Warrants for an interim dividend for the past half-year, at the rate of 6 per cent. per annum on the preference shares, have been posted by the Western Counties and South Wales Telephone Company, Limited.

Grange Syndicate, Limited.—This Company has been registered by Courtnay, Croome, Son, and Finch, 9, Gracechurch-street, E.C., with a capital of £2,000 in £5 shares. Its object is to develop Groth's electric tanning system. Registered without articles of association.

PROVISIONAL PATENTS, 1890.

JULY 28.

11788. **Improvements in electric arc lamps.** Samuel Pleasants Parmly, 1, Quality-court, London. (Complete specification.)

JULY 29.

11816. **The electric furniture polish reviver.** Martha Maria Stainer, 28, Upper Bath-street, Southampton.

11817. **Improvements in electric light fixtures.** Fred Hampson Aldrich, 323, High Holborn, London. (Complete specification.)

11842. **Improvements in the deposition of metals by electrolysis.** George Lee Anders and John Ronald Shearer, 11, Victoria-street, London.

11862. **Improvements in electrostatic measuring instruments** William Edward Ayrton and Thomas Mather, Central Institution, Exhibition-road, London.

11863. **Improvements in electric switches.** William Winstanley Strode and Charles George Gill, 70, Chancery-lane, London. (Complete specification.)

11883. **Improvements in the distribution of electricity, and in the apparatus employed therein.** Thomas Tomlinson, 24, Southampton-buildings, London.

JULY 30.

11919. **Improvements in the manufacture of lead wire, suitable for electrodes and for other purposes, and in electrodes made of such wire.** Jules Legay and Lucien Legay, 46, Lincoln's-inn-fields, London.

JULY 31.

11962. **Improvements in electric bells, bases, covers, and parts.** Edward William Lancaster, Albert Works, Graham-street, Birmingham.

11977. **Improved means for communicating sound to or from a phonograph.** George Edward Gouraud, 191, Fleet-street, London.

12009. **Improvements in electric indicators and in bells, applicable also to other purposes.** John Samuel Ross, Britannic Works, Bradmore-lane, Hammersmith, London.

AUGUST 1.

12094. **An electric fuse for firing guns.** Richard Morris, 28, Southampton-buildings, London.

AUGUST 2.

12119. **An appliance for holding the brushes of dynamo-electric machines while being repaired.** Henry Hollingdrake, 17, St. Ann's-square, Manchester.

12169. **Improvements in and relating to apparatus for measuring electrical energy.** Lucien Alfred Wilhelmine Desruelles and Raphael Fenelon Odile Chauvin, 45, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1881.

5159. **Galvanic batteries.** Crompton and FitzGerald. (Third edition.) 6d.

1889.

11242. **Dynamo-electric, &c., machines.** Siemens Bros. and Co (Siemens and Halske). 11d.

11501. **Electric fuses and detonators.** Ward and Gregory. 8d.

12982. **Electrical switches.** Barton. 6d.

13371. **Telegraphic apparatus.** Parker and Fairall. 8d.

13859. **Regulator for electric lighting.** Houghton. 6d.

17276. **Incandescent electric lamps, &c.** G. and W. Donovan. 8d.

17762. **Electrical switches.** Rawson and White. 6d.

17763. **Electrical switchboards, &c.** Rawson and White. 8d.

1890.

4660. **Heating and cooking by electricity.** Butterfield and Mitchell. 8d.

7003. **Electric motors.** Duncan and Carpenter. 8d.

8197. **Graphophones, phonographs, &c.** Johnson (Edison United Phonograph Company). 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	10

NOTES.

Welders.—There are 108 electric welding machines now in active commercial use.

A Sounder.—Is a telegraph operator, it is asked, who reads by sound an ear-sighted fellow?

Tablet to Gaulard.—On the 3rd of this month a tablet in memory of M. Lucien Gaulard, of transformer fame, was unveiled with due solemnity at Lanzo.

Electric Fans.—Ventilating fans, driven by electric motors—last year hardly known—now are said to be almost universal in the houses of the southern cities in the States.

Electric Census Taker.—The electric census computer, which we described in detail some time back, is estimated to save over £100,000 in compiling the returns of this census.

Electric Ozone.—Before the Academie des Sciences in Paris, on July 15, M. Boillot presented a note upon the "Use of Ozone produced by the Passage of Electricity to Combat Epidemic Diseases."

Another Exhibition.—The Spanish Commission formed to celebrate in 1892 the 400th anniversary of the discovery of America by Columbus, has decided to hold a universal exhibition in Madrid.

Paris Finance.—It appears that a combination between the two rival electrical companies in Paris—the Rothschild and Victor Popp—is likely to occur. M. Bleichroeder, the banker of Berlin, is the moving spirit in the matter.

Electric Launches.—Over 40,000 passengers at penny and twopenny fares have been carried in the electric launches at the Edinburgh Exhibition—a speaking commentary on the popularity of this means of travelling.

Train Lighting in Russia.—The Russian Government, anxious to see the wholesale introduction of electric lighting for trains, has decided that all the carriages of the State railways are to be lit by electric light after this month.

Screw Gauge.—It is proposed, upon the recommendation of Dr. Loewenherz, of Berlin, to make the question of screw gauge for instruments of precision one for full discussion and settlement at the forthcoming exhibition at Frankfort.

Electrical Automatic Log-line.—The Committee on Science and the Arts of the Franklin Institute has recommended the award of the John Scott legacy, medal, and premium to D. Antonio Lopez de Haro y Forraté, of Gijon, Spain, for his invention of an "electrical automatic log-line."

Killed by Lightning at Cricket.—At Heanron, Derbyshire, on Tuesday a man named Stirland, aged 50 years, and a boy named Joseph Woodhouse, aged 11 years, were killed by lightning whilst watching a cricket match. Three other persons were seriously injured by lightning at the same time and place.

Bishop Stortford.—The Bishop Stortford Local Board have decided to grant the application of Messrs. Ackland and Nockolds for a provisional order for the Bishop Stortford Electric Lighting and Steam Laundry Company, subject to such modifications in the draft provisional order as might be deemed necessary.

Burma Lighthouses.—The condition of the Burma lighthouses has, it appears, been attracting the attention of Trinity House. Mr. W. T. Douglas, a member of the Institute of Civil Engineers, was sent out last spring, and made a thorough inspection of all the lighthouses, and his report is expected shortly.

Railway Station Lighting in Germany.—The electric lighting of all the railway stations of Berlin and its suburbs, under one organisation, is proposed; several large generating stations are to supply the stations by cables running along the lines. The scheme is under the consideration of the authorities.

Exeter.—The Special Committee on electric lighting at Exeter have recommended that the question be deferred until the Exeter Electric Light Company had submitted to the Council a draft of their proposed provisional order. This was agreed to, a disposition being shown amongst the Council that the lighting should be kept within their own hands.

How to Increase Dividends.—It is possible, says the *Financial News*, to select securities in tramway companies which will yield a comfortable 5 per cent. In the time to come, when tramway directors have cut down their working expenses at least one-half by substituting electricity for horses, the return must be proportionately greater.

Florence.—We see it is stated that the authorities of Florence are negotiating with the Internationale Elektricitäts Gesellschaft of Vienna for the erection and working of a central station for supply of electric light. The station is to be established outside the town upon the alternate-current system, with transformers of Ganz and Co., and will be for the supply of current for 5,000 to 10,000 lamps of 16 c.p.

Graceful Arc Lamps.—The Rothschild Electric Company in Paris have recently adopted a new type of arc lamp, the form of which is extremely graceful. This is an example that might be followed by other companies. If they cannot design them themselves, there are many architects or designers who would do so, and the brass or iron workers of Paris would be glad of a new outlet for their designing faculties.

St. Saviour's.—The Paving and General Purposes Committee of the St. Saviour's Board of Works reported at their last meeting that they had considered the letter from the Board of Trade, forwarding copy of a description of the system by means of which electrical energy was intended to be supplied under the London Electric Supply Corporation Order, 1889. Upon the motion of Mr. Hale, the report was adopted.

Barnet.—At the last meeting of the Barnet Local Board, the question of the action of the Board of Trade in enforcing better conditions of working the contract for lighting was discussed, and as the Board had twelve months till the expiration of the electric lighting contract, and possibly would not renew it—in which case it would be not worth while to enforce other conditions—the consideration of the matter was adjourned to next meeting.

Southend Electric Railway.—Over 3,000 persons were carried on this railway on Bank Holiday, which was opened ready for the holiday excursions on the Saturday previous. Three times this number might have been carried had sufficient car accommodation been provided. On the Tuesday 2,600 persons travelled on this line. On Friday the pier was lighted by electricity, Messrs. Crompton

having provided seven arc lamps for the pier and the new pavilion.

International Journals.—German enterprise is again to the fore with a new organ for commercial propaganda under the title of *International Industrial Review.* This paper is issued by the International Patent Utilisation Company, of Lubeck, and is published in that town; subscription, 5s. for six months. The contents consist of interesting industrial and commercial notes, and the speciality of the journal is that the matter is given simultaneously in three languages—English, French, and German.

Tenders for Brussels.—The 1st of August was the date given for the receipt of tenders for the electric lighting scheme for Brussels. Four tenders have been received by the Municipality. The first is a combined tender by Messrs. Siemens and Halske, the Allgemeine Berliner Electricitäts Gesellschaft, and the Compagnie de l'Electricité de Liège; the second is by M. Patin, of Paris; the third by MM. Ganz et Cie., of Buda-Pesth; and the fourth by the Société Electrique of Brussels. It is understood that no decision will be come to on these tenders until October.

Pocket Telephones.—A telephone for the pocket has been introduced by Hermann Hannemann, of Berlin, S.W. Electric bells, it is said, are now to be found everywhere. Why not use the wires for telephoning as well? This pocket telephone is to be connected to the bell wires of hotels, hospitals, etc., as well as private houses, and it is hoped that when everyone carries his telephone in his pocket, and when wall sockets are universal, everyone will be able to speak to distant rooms, or even houses and towns, by simply taking out their telephone as they would their watch.

Jacquet Accumulators.—MM. Jacquet Frères, of Vernon (Eure), France, have introduced a type of accumulators which they consider a great improvement on old forms. The grids are large and the exterior of the whole plate is sinuous, so that any apparent lengthening or expansion is taken up. The metal of which the grids are formed is rigid and inoxidisable. The arrangement of active material is such that over 62 per cent. of total weight is active, a result claimed as superior to other forms. An illustration of the cell is given in the *Revue Technique des Inventions* of Brussels.

Crystal Palace Classes.—On Saturday last Sir James Nicholas Douglass, F.R.S., engineer-in-chief to the corporation of the Trinity House, and member of the council of the Institute of Civil Engineers, distributed the certificates in the lecture-room of the school at the Crystal Palace to the Crystal Palace Company's School of Practical Engineering, awarded for the summer term, 1890. The examiners for the term were Mr. A. R. Sennett and Mr. S. H. Cox, who reported that the electrical section was a valuable addition to the work, in view of the great advances recently made in the practical applications of electrical science.

Why the Kemmler Experiment Failed.—Electrician Barnes, who was in charge of the dynamos at Auburn Prison, says an American dispatch, has come out finally with the whole truth as to why Kemmler's execution was bungled. It would have been a complete success but for the fact that the dynamo shafting was not lined up properly so that the pulley could run true. The belts were new, had not got the stretch out of them, and under full pressure half the belt left the pulley, causing the machine to run down to half speed. The electricians in the dynamo-room were doing their best to keep the belt from flying off altogether until the man was dead.

Dublin Science and Art Buildings.—In the House of Commons last week, in answer to Mr. P. O'Brien, Mr. Jackson said that four firms were invited to tender for lighting the new Science and Art buildings in Dublin by electricity—viz., Messrs. Siemens Bros. and Co., Messrs. Johnson and Phillips, Messrs. Edmundson and Co., and the Brush Company; and tenders were received from the three first-named. He was not able to state to what extent any of the firms are manufacturers of electrical plant. Messrs. Edmundson's tender for £8,375, being the lowest, was accepted; the contract with them contains no stipulation as to giving a preference to any firm.

Telegrams by Telephone.—In France, as in England, there are many hamlets and villages to which the network of telegraphs has not yet extended, and persons living there are obliged to pay a heavy fee for the carriage of a dispatch from the nearest telegraph office. In France a measure has just been decided upon which will reduce this fee to twopence halfpenny, and at the same time almost entirely do away with the delay occasioned by the carriage of the dispatch by hand. All communes which have not a telegraph office are to be connected with one by telephone, through which the dispatches received by telegram will be forwarded verbally, the dispatch being later on sent by post.

Woodhouse and Rawson's Excursion.—The contract department of the above well-known firm held their annual excursion on Saturday, August 2nd, when a most enjoyable day was spent by a number of the employés, Brighton being the scene of revelry. After dinner everyone present was pleased to hear of the rapid strides the department had made during the past year, and musical honours were accorded to the health of Messrs. R. J. Jones and B. Thomas, their energetic engineers. Although the holiday makers entrusted themselves to the tender mercies of the London, Brighton, and South Coast Railway Co., no one was many years older when they landed back to London Bridge.

An Electric Town.—A young man going through a course of electrical engineering at the Thomson-Houston works in Lynn, writes to his friends in Florida the following details, reproduced in the *Scientific American*: "Here I am at last. I started at work in the Thomson-Houston electric factory last Monday. To say I am surprised is putting it mildly. There are over 4,000 men employed in this factory. It is a good-sized town in itself. My first position is in the expert department adjusting and testing arc lamps. I am to go through a very thorough course, and be turned out a full-fledged electrician, but it comes very severe on a lazy devil like me to go to work at 6.30 a.m., and continue until 6 p.m. But if others can stand it, I can."

Maintenance of Accumulators.—The spread of the employment of accumulators for traction work is, as our readers are fully aware, dependent largely upon the question of maintenance of the cells. We are pleased to hear that arrangements are practically concluded by which the accumulators will not only be supplied but guaranteed and maintained at certain specified rates for ordinary traction work on tramcars. This action will have the effect of allowing the running expenses to be calculated within an allowable margin, and enable electrical contractors

accumulator is paramount, and no comparisons between direct current and storage avail. Economical storage is the only factor which can make electric omnibuses a success, and symptoms are not wanting to show that this will be done.

Telephone Trunk Lines.—The Western Counties and South Wales Telephone Company has now connected its centre in Southampton with all the important districts in the South and West of England. In about a month's time the whole ot the South Wales district will be linked to Birmingham, and, through Bath, Southampton will join the South Wales circuit. Engineers are soon to be engaged upon this extension of the line, working from Winchester *viâ* Salisbury, and the Southampton section will be taken up directly the Birmingham and South Wales portion has attained completion. Next season the company contemplate the extension of their line *viâ* Basingstoke to Reading, where they intend to join the Royal South of England system, and thus establish continuous telephonic communication from the West of London. By an agreement made with the Hampshire constabulary authorities, intercourse through the medium of the company's wire is to be made between the various police stations of the county, arrangements having already been made for the connection of the stations at Woolston, Bitterne, Shirley, Eastleigh, and Winchester. Public exchanges are now in existence at Totton, Redbridge, and Lyndhurst, and in the course of a month or so there will be call-rooms at Bishopstoke and Woolston.

Agriculture by Electric Light.—In the botanical department of the Cornell University there have recently been made some very curious experiments in the cultivation of plants under electric light. A number of flowers and of vegetables have been placed where the rays of powerful electric lamps fall upon them night and day, and their growth is compared with that of others of their own species planted at the same time and under similar conditions, except in the matter of light. The first and most noticeable effect of this treatment is an enormously increased rate of growth. The plants which are lighted seem to work day and night, and to become especially luxuriant in foliage. The vegetables shoot forward with great quickness; peas, for instance, become in a few weeks two or three times as tall as their brethren living by common daylight; and the same thing is true of all the plants. When it came to seeds or fruit of any sort, the matter was entirely different. Here the plants which had grown slowly and by daylight were ahead. It is true that the pea which grew by electric light came to bearing much sooner than the other, but its hastily made pods had very few peas, often only one, and these of an inferior quality. In every instance the reproductive powers of the plant seem to have been most strongly affected, being sacrificed to mere foliage and rapidity of increase in general size.

Maxim-Weston.—So the poor old Maxim-Weston Company is to be wound up and finally to go into limbo. It has struggled on a long time, and at one time hopes were entertained that it might pull through and yet serve a useful commercial purpose, even though it did not prove a bonanza for its shareholders. But such transient hopes have been doomed to fail, and at a special meeting held at Winchester House a winding-up resolution was proposed, as follows: "That it has been proved to the satisfaction of the meeting that the company cannot, by reason of its liabilities, continue its business, and that it is advisable to wind up the same; and, accordingly, that the company be wound up voluntarily." Mr. J. B. Gooding presided, and, in moving the adoption of the resolution, said although £1,500 had been promised by way of debentures, the sum obtained was not sufficient to admit of the company's continuing business. The company had enough to pay its liabilities, so that it would drag nobody to the wall with it. The liquidators of the old company refused to assign the effects to the new company, and required that all proceeds should be deposited at the company's bankers pending settlement of the action between the company and Mr. Watt. He blamed the solicitors of the company for not requiring the old liquidators to convey the effects to the new company. After a long discussion the resolution was carried, and Mr. Marks and Mr. Hodgson were appointed liquidators, an amendment, moved by Mr. Hembling, to the effect that Mr. Newson Smith should be appointed, being defeated.

Dangers of Ship Lighting.—We inaugurated a few weeks ago a crusade against the bad workmanship—in some cases disgracefully bad workmanship—which has been carried out on board steamships—sometimes not less so on board the fine Atlantic liners than in smaller and less well fitted boats. This arises, as we have pointed out, from owners or chief contractors accepting low tenders without definite specification, and, more particularly, from the apparent utter lack of intelligent and official inspection of the manner of carrying out the installation such as is everywhere the case on land. We are glad to see that our contemporary *Industries*, who is wont to give considerable attention to ship matters, is taking the matter up with some spirit. "We often wonder," says our contemporary, "that there are so few serious accidents on board some of the electrically lighted steamships. On one of the very best of the American liners, for example, the return is made by the ship, and the return wires from the lamps are stapled down with the leads. When we were travelling by it recently there was a short circuit, which went on intermittently, without blowing any fuses, merely putting the lamps out now and then. There would be a sound like tearing calico, and the lamps would dip. Probably a bare main was dangling against a girder. Presently a man with some insulation patched the fault up, and he considered the accident nothing unusual. We have so many rules and regulations on land that it is difficult to fit up an installation to suit them; surely the Board of Trade or the insurance companies should see that sea work is done correctly." We believe the ship insurance companies are now giving serious attention to the matter, not before it is wanted, and the Board of Trade ought, in the cause of common safety to life, to issue definite regulations as to the electric lighting on board ship and make some arrangements to see that these are carried out, both on ships already fitted and upon ships newly installed. Otherwise we may find a terrible accident laid to the charge of the electric light when one of these supposed "insignificant" small fires is not discovered in time.

South London Electric Railway.—The shareholders in the new underground electric railway met at Winchester House on Tuesday to receive a report from their directors about the progress of the railway. Mr. Mott said that, although he hardly liked to pledge himself to a date, he hoped that the end of next month would see the lines at work. The construction of the lifts which will convey passengers from the top to the underground stations had caused the most delay, but they had now made good progress. The under stations were all finished, and the

ON SOME EXPERIMENTS IN RADIOMETRY.*

BY A. R. BENNETT, MEMBER.

In the course of some experiments with radiometers the author has been able to detect effects which are of interest, and which, if observed before, have not been published so far as he is aware.

Some of the experiments detailed may not bear any apparent relation to electricity; but the fact that electrical vibrations and those which give rise to heat and light are now admitted to be but different phases of the same phenomenon must be the author's excuse for troubling the Institution with them.

Rotations of the vanes of ordinary radiometers can readily be produced by electricity.

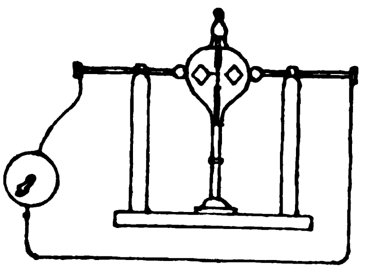


FIG. 1.

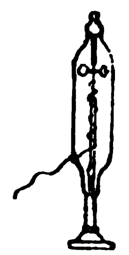


FIG. 2.

An unusually sensitive radiometer placed between the poles of an influence machine, Fig. 1, has its vanes strongly affected. As a rule, oscillation to and fro only is set up, but this may readily be converted into rotation by timing the impulses from the machine to the swinging of the vane, or by giving the vane an initial start by lighting a match, or jerking it. Then rotation continues so long as the machine is worked. Generally, but not invariably, the motion, if not started mechanically in the reverse, is in the same direction as would be produced by heat. After the machine stops the vane continues to rotate for a time, even after the knobs of the machine are brought together; and when it is stopped a single impulse is sufficient to set it off again. In the dark the bulb appears filled with the usual phosphorescent light.

The effect appears at least partly electroscopic, since on starting, the nearest vane is usually attracted toward, and then repelled from, the knob.

Placed against one pole only of the machine the vane oscillates feebly, but can be nursed into rotation.

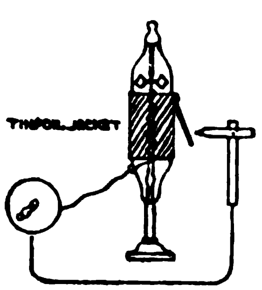


FIG. 3.

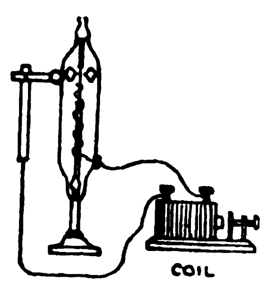


FIG. 4.

With radiometers of special make more marked effects can be obtained. Several instruments having vanes fitted with metal caps working on pivots connected to the outer air by wires fused in the glass were prepared, Fig. 2.

Such radiometers really form condensers or Leyden jars having the inner coating—the vane—free to move. The dielectric is the rarefied air, and the glass the outer coating.

When the vane is connected to one pole of an influence machine, it rotates until the condenser of which it forms a part is fully charged, and then stops; when the current is arrested the vane rotates again in the same direction until the greater part of the charge has been lost. So, by timing the impulses from the machine, continuous rotation can be produced. In the four-vaned instrument on the table the motion produced is in the reverse direction to that due to heat, the black being seemingly attracted; but in that instrument the vanes are bent at an angle which would naturally render the impulses effective in the direction indicated. In the two-vaned instrument, also shown, the vanes have no bias, and the motion is sometimes in the one direction and sometimes in the other. This charge and discharge effect is produced feebly when the instrument is standing in air, the vane only being connected to the machine. When the glass is brought near to or touches the opposite pole it becomes better pronounced, and when the glass is coated with tinfoil and put in contact with the opposite pole it becomes strong and invariable. If the foil is removed out of actual contact but retained within free sparking distance the vane no longer has periodic dead points, but discharges constantly to the outer coating, and rotation continues so long as the machine is worked. The process may be reversed by connecting one pole to the foil and drawing the sparks from the vane by means of its connecting wire. The direction of rotation continues, however, as before. If the end of the vane wire be of small gauge—No. 40, for instance—it vibrates violently while discharging, and with such rapidity that it seems double-ended, two perfect, and apparently motionless, images of the ends appearing half an inch or more apart.

Continuous rotation may likewise be attained by means of an automatic discharger consisting of a strip of foil hanging from the outer coating of the radiometer opposite a contact point, which may be earthed or connected to opposite pole of machine, Fig. 3. The foil diverges from the glass when the condenser gets charged up, and, making

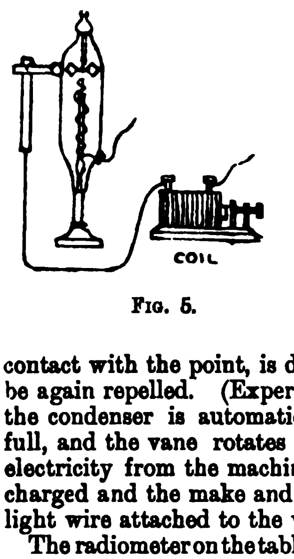


FIG. 5.

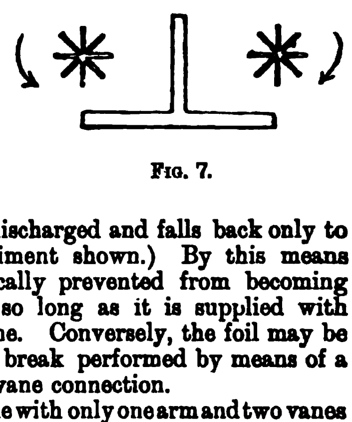


FIG. 7.

contact with the point, is discharged and falls back only to be again repelled. (Experiment shown.) By this means the condenser is automatically prevented from becoming full, and the vane rotates so long as it is supplied with electricity from the machine. Conversely, the foil may be charged and the make and break performed by means of a light wire attached to the vane connection.

The radiometer on the table with only one arm and two vanes is extremely sensitive, and exhibits the foregoing condenser effects in a marked degree. While charging or discharging it revolves with such rapidity as to make the arm appear a circle, and when fitted with an automatic discharger each secondary discharge after the main one has been effected is accentuated by a kick. The rotation in this case is right and left indifferently, apparently according to the direction in which it first obtains an impulse. (Experiments with this instrument were shown after the paper.)

Experiments were made with these radiometers with the current from a Rhumkorff coil.

Placed between points or knobs connected to the secondary of the coil, an ordinary radiometer could be got to rotate if an initial jerk were given either to left or right. Left to itself it oscillated only, the tips of the vanes being alternately attracted towards the knob and repelled from it.

With a special radiometer connected as in Fig. 4, oscillation only could be got with dry glass, but on wetting the circumference of the tube round the vane, rotation was immediately set up in the reverse direction to that caused by heat, and continued until the glass dried. Merely breathing on the glass caused rotation to recommence. The effect cannot be wholly due to the fact that the moisture made a conducting ring round the glass, as a band of tinfoil had no result, unless wetted on the outside, when very

* Paper read at the special meeting of the Institution of Electrical Engineers at the Edinburgh International Exhibition, July 17, 1890.

on making a cap of tissue paper and balancing it on a needle point it proved to be so. The cap is under some circumstances more delicate than the vane, and more sensitive to heat than the most sensitive Crookes's radiometer that could be procured. It was found that when a vane or a light paper cap was placed within a circular screen not quite closed, Fig. 8, a ray of heat suffered to fall on the screen near the opening would set up air currents, and rotation of the vane or cap, which would continue as long as the heat was applied. The direction of rotation depends on the form of the aperture in the screen. When opened out, as in A, Fig. 8, so that the heat, indicated by the dotted arrows, falls partially within the screen, the vane or cap is repelled from the source of heat; when, as in B, the ray falls on the back of the opening, it is attracted. The direction of rotation may thus be changed by adding to the screen; when, as in B, the vane is being attracted, the placing of a book or other object, as in E, immediately causes it to stop and reverse.

This arrangement is of extreme sensitiveness. If the observer keeps well away, rotation will continue after sunset and under a cloudy sky when the opening of the screen is exposed to the window. It excels in this respect a Crookes's radiometer of ordinary make, which on several occasions was noticed to give up work before the screened paper cap. Simultaneous rotation of two vanes or caps in the same, Fig. 9, or in different, Fig. 10, directions may be secured with one screen.

The movements of neighbouring bodies are not of so much importance as with unscreened vanes, as except in the direction of the opening, exterior influences, unless very violent, are intercepted. Placing the body across or near the opening disturbs and will even stop rotation.

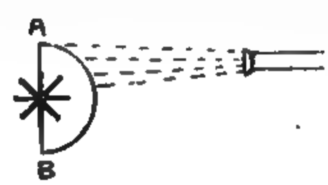


Fig. 11.

Rotation may be set up by applying heat to the exterior of the screen. Thus, a ray of heat falling at A or B, Fig. 11, causes rotation.

Vanes or paper caps protected from the outer air by glass clock-shades will rotate under sunshine or other source of heat, direction being determined by position in respect to wall of shade.

Rotation is produced by placing a heated screen round a vane. Thus, if a tinned iron screen be taken and heated, either uniformly, or at one or more points, it will, when placed over a vane, immediately set up rotation, which will continue, even in the dark, until the screen has cooled to the temperature of the air.

Similarly, a vane inside a screen of good conducting material—as metal—will rotate when heat is applied to one point of the exterior of the screen. This can be shown by applying the tip of a hot poker to the outside of a tinned iron screen.

(To be continued.)

THE CENTRAL STATION COMPANION.

One of the chief difficulties which an electrical engineer has to contend with in central station work is the large number and inconvenience of instruments required for practical testing. This evil is growing daily, and any invention which tends to lessen it will be welcomed by the supply companies. A combination instrument, called the Central Station Companion, has just been invented by Mr. H. J. Dowsing and Mr. A. A. Day, the leading features of which are its compact form and simple arrangement, qualities which are to be greatly recommended. Various combinations have been made, but the present form is probably the one which affords the greater variety of uses in the smallest possible compass.

The central station companion, as usually made, is of the following dimensions—viz., 6in. by 8in. by 4in., and contains (1) an ordinary detector or galvanometer, (2) a Wheatstone bridge to measure from ·05 to 50 ohms, (3) a standard ohm, (4) a variable resistance or rheostat, (5) a set of small accumulators for giving light when testing, (6) necessary switches, connections, contacts, etc. If required, a 10-ohm standard coil can be inserted to increase the readings tenfold.

An essential feature of the central station companion is its simplicity. Any workman can use it, and as there are no loose keys, complicated coils, or calculations to make, mistakes cannot occur.

To use as a detector, the ends of the circuit must be connected to the two end terminals, the key pressed when the battery and galvanometer are put into circuit.

To use as Wheatstone bridge, all that has to be done is to insert the resistance to be measured between two of the terminals and turn the knob in front (which inserts more or less resistance) while pressing keys, until there is no

The Central Station Companion.

deflection in the galvanometer. Then read the actual resistance from the scale. As above stated, there are no calculations required, and the resistance in ohms is read off direct. With a little adaptation the instrument can be used as a potentiometer, or for comparison of potentials by Poggendorff's method.

The incandescent lamp is a useful addition to the testing set and makes the instrument useful as a portable lamp, and the battery can readily be charged at any of the stations where low-tension continuous-currents are in use. If, however, it is preferred, a special form of Leclanché can be fitted which will run a small lamp for a few minutes, giving ample time to make intermittent tests. It is an important point in connection with this testing apparatus that it can be made to measure higher or lower resistances as required for special purposes. The scales can be given a large range of reading at any desired point, so that accuracy may be assured.

Perhaps the greatest arguments in favour of the companion beyond its compactness and portability, is the low price at which it can be made. One of the ordinary size can be obtained at about half the cost of the cheapest form of Wheatstone's bridge.

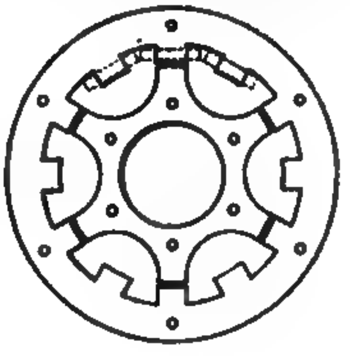
The companion is made by Messrs. Day, of 60, Queen Victoria-street, who will give any further information required.

AN EXTRAORDINARY DYNAMO.

The accompanying illustrations show the details of a dynamo-electric machine so extraordinary in its structure and electrical properties as to be fairly revolutionary; a machine quite as unique in its way as the Duncan motor, to which reference was recently made in our editorial and other columns. The new machine is the invention of Prof. Elihu Thomson, and its special marked properties are total absence of external magnetic field, and almost complete freedom from hysteresis.

Fig. 1.

Fig. 1 shows a section of the machine. The revolving portion of it consists of a shaft surrounded by a massive iron cylinder, bearing on its central portion the laminated mass of iron that forms the internal pole-pieces. The appearance of this part of the machine is shown by Fig. 3. This iron mass revolves within a pair of iron sleeves, which carry the bearings of the machine and the magnetising coils, which are thus fixed and wound on bobbins on either side of the revolving poles. The end plates of these massive sleeves are joined by a cylindrical casing of iron completely shutting in the machine. On the interior of this casing, and immediately surrounding the revolving pole-pieces, is a ring with inwardly pointing poles barely clearing the revolving ones. Looped around these poles are the armature coils. The magnetising coils of the



Figs. 2 and 3.—Section and Pole-piece of Dynamo.

machine are so wound as to produce, in the revolving portion, consequent poles of the same polarity in each of the polar projections. The magnetic circuit extends through the internal cylinder and its surrounding sleeves through the outer casing, and forms consequent poles of opposite polarity to the revolving ones in the polar projections that point inward. There is thus no external field whatever.

The action of the machine is as follows: The moving field poles carried around by the revolution of the core-pieces pass in front of the coils in which the currents are to be induced. The lines of magnetic force from these pole-pieces cut transversely across the wires on the coils, since these lie in the proper direction to be so cut, or at least the sides of the coils parallel to the axis so lie, and in them are generated impulses of current. The direction of the winding and connection is such as to make the effect accumulative in the coils, so that if the polar projection passes, as in Fig. 2, over the centre of one coil to that of the next, its lines of force are caused to cut the wire lying between these centres. Impulses of current would thus be set up in both coils, and as the coils are wound each impulse will be superadded. The number of inward pointing poles may be, as in this case, double that of the outward pointing poles; or it may be the same, when the action becomes a simple cutting in succession by the lines of force emanating from the polar projection, of one side of a coil, or of one side of all the coils taken together, and immediately afterward the other side of the same coil or set of coils.

These actions will be repeated in the coils every time a polar projection passes the wire on either side of the coil, so that if there be six poles, and the revolution of the machine be at the rate of 1,000 turns per minute, there would be 6,000 complete alternations of current per minute. These actions of induction will be accomplished without reversal of magnetism in the core-piece, or in the laminated ring structure supporting the coils, and hysteresis will thus be reduced to a low amount. Of course, all cannot be obviated, for the reason that there is a changing of the magnetism of the pole-pieces in any case; but it will be reduced to a quantity far less than if the same mass of iron were reversed as usual. It is not necessary then to laminate either the revolving or the stationary poles, and it is obvious that the machine, although described as a dynamo, is equally applicable to the construction of an alternating motor that would possess many desirable qualities; or by the addition of a commutator, be suited to the production of continuous currents.

We think that this description is sufficient to indicate the remarkable properties of the new machine, and although as yet no details of its efficiency are at hand, it certainly appears to be a very simple and effective form of generator or motor. The construction is especially easy and the winding admirable, since there are no moving coils, and therefore no moving contact of any sort, the wires to both field and armature being simply connected to binding posts. The machine certainly is very creditable to Prof. Thomson's inventive genius, and, unless we much mistake, will soon be heard from commercially.—*Electrical World* (New York).

CORRESPONDENCE.

THE LINEFF TRAMWAY SYSTEM.

To the Editor of the Electrical Engineer.

Sir,—I have to thank you for the valuable space you have so kindly placed at my disposal with reference to my magnetic conductor; but I think there must be a limit even to an editor's patience, and with your permission I will close my correspondence on the subject. Mr. Holroyd Smith has too many "doubts," and his "snake trick" evidently gave him more trouble than satisfaction, otherwise he would not require so much "information."

Of course, Mr. H. Smith cannot expect me to give such information for nothing, or to lay open before him all my memoranda, diagrams, etc., in fact, the whole experience and practical knowledge I gained while studying the question.

I can assure him, however, that what seems very difficult to him might not be so puzzling to others, and his "doubts" are capable of a very easy and satisfactory solution.

With regard to his claims of priority, of course, he knows his remedy, but he must *prove* them.—Yours, etc.,

Alex. L. Lineff.

11, Queen Victoria-street, E.C., Aug. 13.

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We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

PROVISIONAL ORDERS.

The periodical reports of the Board of Trade form excellent landmarks as to the activity of electric lighting schemes. These reports grow in size, showing that an increased number of applications have to be considered and dealt with from year to year. Perhaps the most interesting part of this report is the summary given at the end of the list of applications on p. 13. Before further referring to this summary it may be well to say that the report can be purchased for threepence at the Queen's printers, so that it is unnecessary for us to give the list of applications. We have, however, given elsewhere the appendix to the report, which deals with the regulations of the Board of Trade for the protection of public safety. Of course these regulations will be subject to constant revision. But of these hereafter. The summary shows that of the 161 applications, 45 were made by local authorities and 116 by companies or individuals, 23 relating wholly or in part to London. The orders granted to companies have in every case been granted with the consent of the local authority for the district. In several instances applications were made by the local authority, and also from one or more companies for the same area. In such cases the Board of Trade have, in accordance with their rules, given the preference to the application of the local authority. It is noticed also that in the orders and licenses granted to local authorities the Board of Trade have, after careful consideration of the representations made to them in favour of such a course by the local authorities, inserted a clause authorising the local authority to transfer their powers, duties, and liabilities to any company or person with the consent of the Board of Trade.

There are a good many lessons to be learnt from these reports and from the actions of the Board of Trade. The industry has been and is under the influence of good old grandmotherly and fussy legislation; red tape is rampant and supreme. Things must be taken as they are, and not as they ought to be, so that, grumble as much as we will, it is necessary to comply with the regulations.

In the first place, the Board of Trade has dealt hardly with company promoters, for so must many of the applicants be classified. A clique of promoters, local or otherwise, fasten their eyes upon a promising town, or a number of towns, and without the slightest, or upon the merest shred of, support apply for a provisional order. The idea is to obtain the order, float a company, get promotion-money, and do likewise elsewhere. In many cases there is no evidence whatever that the applicants really intend business themselves. They are harpies playing a profitable game upon a confiding public. The game is pretty well played out, and the constant reiteration of the remarks in this report that "The promoters failed

The tramway in question forms one section of the Birmingham Central Tramways Company's system, and extends from the city along Suffolk-street, Bristol-street, and Bristol-road to Bournbrook, being three miles in length and double line throughout. For about 12 years the above route was worked on the 4ft. 8½in. gauge as a horse tramway, but having become very dilapidated and dangerous, it has recently been reconstructed, to the same gauge and in a similar manner as the remainder of the company's lines, in connection with which a generating station has been erected at Bournbrook, for the purpose of enabling the accumulator system of electric traction to be adopted.

The tramway commences in Birmingham (Navigation-street) close to the steam tram terminus in John Bright-street, the curve from Navigation-street into Suffolk-street forming nearly an angle of 90deg., with a radius of about 40ft., and on a rising gradient of 1 in 28. After leaving this point the gradients and curves are all easy except a grade of 1 in 32 for about 200 yards. The rails are of steel, girder section, 6in. deep with 7in. flange, weighing 92lb. per yard, the ends of all rails being punched with three holes so that the steel fishplates, each 2ft. long, are secured with six ¾in. bolts. In order to further strengthen the joints, wrought-iron sole-plates, 10in. long and ⅜in. thick, have been provided, one under each joint, firmly secured to the flanges of the rails by eight steel clips, bolted to the sole-plates. Steel tie-bars are fixed every 9ft., 1½in. deep and ½in. thick. The points are of Siemens open hearth steel, and were supplied by Messrs. T. H. Lloyd and Co., Limited, of James's Bridge. The rails rest on a bed of Portland cement concrete 6in. thick. The whole area to be paved, including a space of 2ft. 1in. outside the rails on each side, was floated with fine cement concrete to receive 5in. by 3in. creosoted wood blocks, boiling pitch and tar being poured into the joints for about 1in. in depth, the remainder being flushed up with cement grout. In order to form a bond with the macadam, a serrated margin of granite setts was placed at the outside of the paving.

Fig. 1.—Bournbrook Depot.

Depot and Generating Station.

The depot is situated at the Bournbrook terminus of the tramway, at a distance of about 80 yards from the main line, on a plot of ground comprising about threequarters of an acre in area. The yard and block of buildings, containing traffic office, engineer's office, men's room, stores, accumulator-room, switch-room, smithy, lead-melting store, fitting-shop, engine-room, boiler-house, and coal store form the flank of the car-shed, and are constructed with their floors at different levels suitable to the natural rise of the ground, with steps leading down into the car shed.

The charging station, 75ft. long and 63ft. wide, where the cars are relieved of the exhausted batteries and supplied with charged ones, forms the front of the depot, and contains four lines of rails, which run through it into the car-shed behind, which is 100ft. long and 63ft. wide. The whole of the trucks in the car-shed and charging station are provided with pits, so that an examination can be made of the motors, gearing, and brakework wherever the car may be standing.

For the removal of the cells to and from the cars there have been constructed four hydraulic elevators, with eight shelves to each elevator, capable of storing sufficient cells for 16 cars, besides which additional storage is provided in the accumulator-room, where platforms are fixed to accommodate sufficient cells for two extra cars. These can be charged at the same time as the cells on the elevator cages, which are not closed in, but are open all round, so that the cells may be thoroughly under control and examination Underneath the whole area occupied by these elevators is a chamber which facilitates examination of the cylinders, rams, and connections, and enables the cages to fall below the floor level

Machinery and Plant for Charging the Accumulators.

The engines and boilers are in duplicate, and each boiler is capable of generating steam for one engine, each engine being guaranteed to deliver 100 h.p. on the flywheel. The two boilers are of steel, multitubular, of the "Economic" safety type, 12ft. 6in. long and 7ft. 6in. diameter, each with two flues 2ft. 4in. diameter, and 70 smoke tubes 3in. diameter, with return smoke-box in front of boiler: each flue has two Galloway tubes, and is fitted with Paxman's patent expansion joint. The usual fittings, double safety valve and fusible plug, are provided. Arrangements are

strips. After the current has passed through the batteries on the cages it returns by means of similar copper strips on the opposite guides to the negative lead, then through the negative terminal fuse blocks, and on to the dynamo. There are also provided portable voltmeters for testing single cells, tachometers for indicating speed of dynamos, and hydrometers for testing the specific gravity of the acid solution. The accumulators, secondary batteries or storage batteries, are of the Elwell-Parker type, contained in vulcanite cells filled with dilute sulphuric acid, and are composed of thin lead grids filled with a paste of red lead or minium, and placed vertically in the cells. There are 19 grids or plates in each cell, 10 negatives and nine positives, each plate being about 8¼in. by 6½in. The plates are kept apart by means of vulcanite insulators, and sufficient space is left between the plates to prevent their being short-circuited in case any of the paste pellets should happen to fall out of the perforation of the grids. When placed in the car, or when being charged, eight cells are placed in a teak tray and permanently connected, three of such trays forming one of the four groups into which the whole battery (when in the car) is divided for controlling purposes. There are 96 cells to each car, giving a total E.M.F. of about 192 volts, and requiring a current of about 35 amperes to charge them, an operation which lasts about 10 hours. The hydraulic cage elevators are so constructed that the cells can be removed at any time, and the operation of charging is commenced by the automatic connection made directly the trays are removed from the cars to the shelves of the elevators.

The lighting of the sheds and shops is by means of 16-c.p. incandescent lamps distributed throughout the building, with wall-plates for connecting with portable hand-lamps. Two 200-c.p. lamps are fixed over the entrance to the charging station.

Fitting Shop and Smithy.

Adjoining the engine-room is the fitting-shop containing lathe, drill, grindstone, with shafting and provision for additional machine tools, the power being derived from an electric motor capable of developing nine brake horse-power, with a speed of 900 revolutions per minute, having slides for tightening belts, etc. A suitable smith's hearth with tools is provided in the smithy adjoining. Between the fitting-shop and the accumulator-room is the lead furnace for melting lead for the plates of the cells. A glazed stoneware tank is provided to contain a store of acid for the renovation of the acid solution in the cells. A portion of the accumulator-room forms the switchroom, separated from the former by a glazed partition of pitch pine matchboarding with a glazed ceiling; adjoining the accumulator-room is a room containing three underground vats or tanks for the storage of oil, formed of slate slabs and white glazed bricks.

Hydraulic Pumping Machinery.

The hydraulic pumping engine and pumps, together with the hydraulic accumulators, are placed in a room in the water tower underneath the tank, and this machinery maintains a pressure of 700lb. on the square inch in the hydraulic pipes. In the same room is placed a wall pump which raises the water from the underground tank (previously mentioned) to the cast-iron tank on the top of the water tower. The hydraulic pipes from the accumulators to the hydraulic elevator are placed in a conduit and surrounded with sawdust to prevent freezing. The top of the conduit is formed of wrought-iron boxes, filled with concrete, so as to enable the piping to be readily accessible.

The floors of the charging station, car-shed, boiler-house, and engine-room are paved with Eureka cement concrete 3in. thick, and the fitting-shop and accumulator-room with wood blocks. The engine-room has a dado 6ft. high, of pitch pine matchboarding, the walls above being plastered and coloured. The ceiling is also matchboarded, and pierced with ornamental coloured lights, and apertures for ventilation. A polished and glazed pitch-pine case, containing fire hydrant, hose, etc., is placed in a prominent position in the engine-room.

The boiler chimney is circular, 110ft. high, and 4ft. diameter at top of cap, which is formed of cast iron, in sections, bolted together. There is a 4½in. firebrick lining with a 3in. air space, carried up about 20ft. from the base of the flue, and climbing irons are built inside from top to bottom. The lightning conductor consists of a copper band 1¼in. wide and $\frac{5}{16}$in. thick, attached to the brickwork by brass clips. The earth-plate is fixed in the underground tank. The yard is paved with 5in. by 3in. granite setts, and there are urinals, w.c.'s, and lavatory for the use of the workmen and the officials. Telephonic communication is provided in connection with the Birmingham exchange.

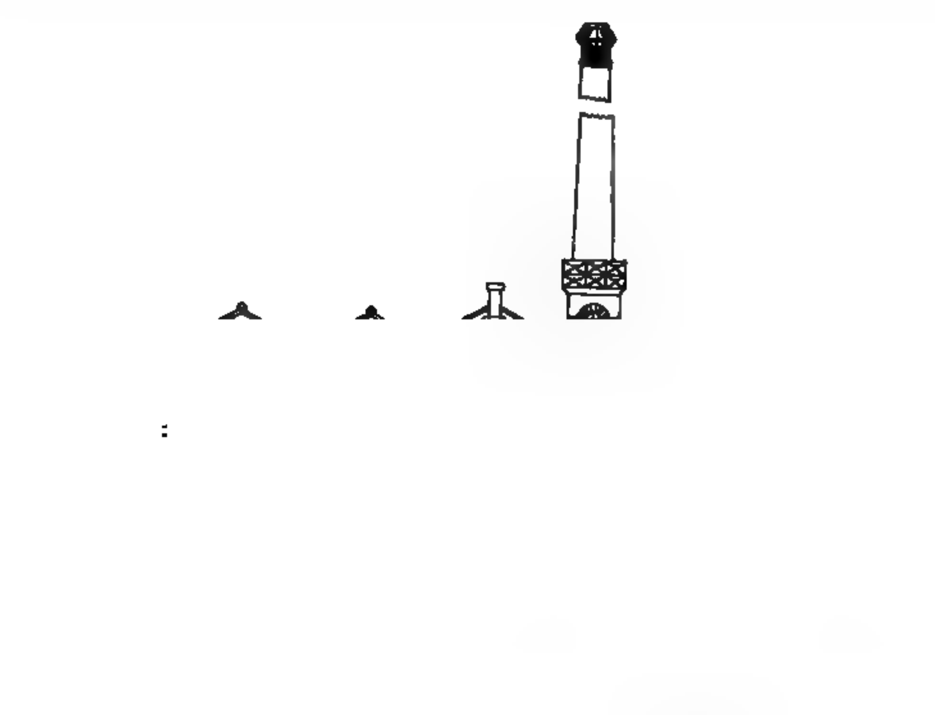


Fig. 3.—Elevation and Section of Depot.

Cars.

The cars have been built by the Midland Carriage Company, Limited, at Shrewsbury, the electrical and mechanical fittings being supplied by the Electric Construction Corporation from their works at Wolverhampton (late Elwell-Parker) and are on the "Julien" principle.

The cars (which are very similar in appearance to the cable cars belonging to the same company) are 6ft. 3in. wide and 26ft. 6in. long, about 4ft. 6in. at each end being occupied by the platforms, and are constructed to carry 24 inside and 26 outside passengers. They are carried on two bogie trucks, about 15ft. between centres, the framework being of channel iron strengthened by two king trusses.

On the top of the cars reversible garden seats are provided, and inside the usual longitudinal seats with a passage down the centre. Below the plate-glass windows

Fig. 4.—Chamber for Hydraulic Elevator.

Half Plan B B. Half Plan C C.

Fig. 5.—Foundation for Hydraul Elevator.

on the outside are polished teak panels, which slide vertically, and afford access to the trays carrying the cells of the batteries underneath the seats. There are six trays on each side of the car, and each tray holds eight cells, there being 96 altogether. The cells are of vulcanite, and the trays of teak, each tray carried on three runners fixed to the car floor. The cells in each tray are permanently connected up in series, and the positive and negative terminals are connected to brass plates attached to opposite ends of the tray. Between each pair of trays is fixed a spring copper contact block, V shaped, screwed to the floor of the car, with the apex of the V pointing outwards, the wings of the V spreading laterally. When the trays are pushed into the cars the two tips of the V pieces come into contact with the brass plates on the ends of the trays, and so the whole of them are automatically connected up. The 12 trays (96 cells) are arranged in four groups of 24 cells each, the whole of the cells in each group being permanently in series, and the four positive and four negative terminal leads are brought up to the switch used by the driver of the car, by means of which the four groups may be connected up with the motor in six different ways.

No. 0.—All the groups separate and disconnected.

No. 1.—All the groups in parallel, but not connected with motor.

No. 2.—The four groups in parallel, all the positives being connected together and with the positive terminal of the motor; and all the negatives together and with the negative terminal.

No. 3.—Half the groups in series and half in parallel.

No. 4.—Two of the groups are connected in parallel, so as to form one group, and the other two are then connected up in series with this couple—so that practically there are three groups in series.

No. 5.—The whole four groups in series.

Thus it will be seen that the whole of the cells are always in use when the car is in motion and fair uniformity of discharge is maintained.

When the switch-handle is at the extreme end, the whole of the batteries are on open circuit, disconnected from each other and from the motor. On being moved into the first position, the batteries are all connected up and ready for work, but not connected with motor. This position tends to equalise the batteries. The second position connects the batteries with the motor, but only gives one-fourth of the total E.M.F., and would be used probably when travelling on the level with a light load. The third position gives half the total E.M.F. The fourth position gives three-fourths of the total E.M.F. The fifth position gives the total E.M.F. of the whole of the 96 cells, and would be used in going up hill with a heavy load. This method of controlling the current is one of the Julien patents, acquired by the Electric Construction Corporation, and does away with the necessity for resistance coils in the circuit.

MOTORS.

The motors are of the Elwell-Parker type, double limb, series wound, and run with 140 revolutions, but a velocity of 700 revolutions per minute is required to maintain a speed of eight miles per hour. There is only one motor to each car, carried on one of the bogie trucks by means of an aluminium brass or steel frame, which has three points of support, two being rigidly fixed on one axle of the bogie, and the other resting on the second axle through the intervention of a strong helical spring.

Thus it will be seen that the motor and its appendages are entirely independent of the oscillation of the car due to variations of load. At one end of the armature are the commutator and brushes, and the other end carries a pinion which gears right and left into two spur wheels carried by countershafts on the brass frame. On these same countershafts are fixed additional pinions, which gear into spur wheels on the two axles of the bogie, and thus the motion of the armature is gradually reduced to the speed required for the car, the proportion being about 6¼ to 1. All the gearing is done by helical teeth.

The switch by means of which the driver controls the current, and therefore the car, is placed on the car platform just underneath the steps, and is quite out of the way of the passengers. The lead, etc., joining the cells up to the switch are enclosed in a teak matchboard casing, the switch being placed on the top of the casing. The part of the car floor over the motor is removable. The cars are lighted by two 16-c.p. incandescent lamps, one at each end. A powerful brake is provided which grips the whole of the eight wheels at the same time, and there is also an auxiliary brake attached.

FIG. 6.—Car Motor.

The whole of the contractors have carried out their work in a most satisfactory manner, especial credit being due to the Electric Construction Corporation for the excellence of the work and materials included in their portion of the installation.

The following list gives the names of the several contractors employed: Permanent way within the city, The Improved Wood Pavement Company, Limited; permanent way outside the city, John Fell, Leamington; depot, John Fell, Leamington; engines and boilers, Messrs. Davey, Paxman, and Co., Colchester; machine tools, Alldays and Onions, Limited, Birmingham; hydraulic elevators and pumping machinery, The Glenfield Company, Limited, Kilmarnock; dynamos, leads, and electrical fittings, The Electric Construction Corporation, Limited, Wolverhampton; cars, motors, and wiring, The Electric Construction Corporation, Limited, Wolverhampton.

Messrs. E. Pritchard, M.I.C.E., and Joseph Kincaid, M.I.C.E., of Birmingham and London (the engineers to the tramway company), designed the permanent way outside the city boundary, also the depot and the electric installation. The works have been executed under the superintendence of Mr. A. W. Pritchard, C.E., for the engineers.

HOW TO ESTABLISH A CENTRAL ELECTRIC LIGHTING STATION.

BY SYDNEY F. WALKER.

(Continued from page 123.)

The battery system combines to a very large extent the advantages and disadvantages of both systems, while it also has advantages and disadvantages of its own.

With this system cables will be smaller than with the low-tension system, not as small as with the high tension. Insulation must be higher than with low tension, and need not be as high as with the transformer system. With this system, too, it should be possible to ensure an absolutely constant supply, provided that good men can be obtained to place in charge of sub-stations, and that they are provided with a liberal allowance of spare cells.

The disadvantages of the system are the want of concentration, giving the superintending engineer so much more work in looking after his men, or, as an alternative, necessitating a very superior and more highly paid staff in charge of the sub-stations, the much greater complication of the apparatus, the larger number of skilled employés necessary, and the extra cost of the installation, owing to the high price of storage batteries. In the matter of maintenance, too, the rents of the sub-stations must not be forgotten, though there may be a diminution of rent of the central

Each dynamo and each engine should run perfectly independently of all the others; there being no connection either electrically or mechanically except through the boiler, and the latter should also be divided as much as convenient. At the same time, it should be practicable for each current to be thrown on to any particular dynamo at a moment's notice by the turning of the handle of a quick-acting switch. The latter must be so constructed that it is not possible for any two dynamos to be connected through the switch, or the result will probably be disastrous, one dynamo forming a circuit of very low resistance for the other. It is not, however, a difficult matter to design switches that will fulfil these conditions, even for several dynamos. In fact, many such switches are in use at the present time.

Do not be tempted to adopt the plan of connecting two or three dynamos to one set of mains. It looks simpler, but in practice it is not so, and gives trouble. At the very least it necessitates much greater attention at the station. The idea upon which the plan is based is similar to that which rules in the text-books, where instructions are given to connect cells in two or three parallels in order to obtain the best result. It is supposed that each parallel will always have the same E.M.F. and the same resistance, whereas they rarely do have when first charged, and never maintain it. So with dynamos running together in parallel. If the E.M.F. at the terminals of each is always the same, they will all simply deliver their current to the mains, and divide the work between them in inverse proportion to their internal resistances. But, in practice, no two dynamos ever do give exactly the same E.M.F. No two engines can be depended on to run at exactly the same speed always. The result is that the dynamo which has the highest E.M.F. prevents the others delivering any current into the mains, until its own E.M.F. is reduced to the level of the others. Should its E.M.F. now fall below that of either of the other dynamos, it ceases to give a current, and so on, so that the work which any dynamo of the group may be doing is quite beyond the control of the engineer unless he has a very careful man watching all the machines in use, and this man has an easily-applied regulating apparatus that he can quickly adjust as the dynamos require it. This means additional skilled labour, and something taken from the possibilities of a dividend without any gain to show in return, unless it be a small reduction of capital for cables, and not always this. With each dynamo and engine working independently, the increase or decrease of the voltage of any dynamo by, say, 1 per cent., or even more, above or below the standard would not be noticed in the lights, while with all the dynamos connected together it might have a very serious effect.

Added to this is the consideration where alternators are used of the necessary rise of voltage at the terminals of the alternator as the work increases, and the converse as it decreases. It will add to the attention required if this rise and fall has to be provided, and also each dynamo has to be kept exactly at a given E.M.F., for each point of the consumption curve.

It has been said that by connecting the brushes together, + to + and − to −, the difficulty is got over, as there is uniform E.M.F. or difference of potential all through, owing to the presence of the connecting wire. There is nothing of the kind; the E.M.F. to be dealt with is that generated by each individual armature, less the charge upon it for the current passing through it, and the connecting wire does not affect this. It only forms another path for the current. Added to this, the cross connections between the dynamos are very troublesome when it is desired to stop any particular one. In a case which came under the writer's notice, in which two dynamos had been connected in every way it was possible—even the two engines that drove them being connected together by a clutch on the countershaft—it was necessary, in stopping either dynamo, to be ready to put the switches out, as the brasswork invariably caught fire, owing to the intense spark that passed. The trouble was completely cured by separating the dynamos and engines, and dividing the work between them when it was heavy, or letting one take all when it was light.

Next, in starting the station, which will be best—to commence with small engines and dynamos and lead up to large ones, or to use large ones at once. This will depend upon circumstances. If a careful canvass of the district covered by the mains brings promises of, say, 3,000 lamps, then the plant laid down may consist of three dynamos and engines, each capable of furnishing 1,000 lamps, and a similar set as spare. If only a small number of promises can be obtained at first, say only 500 lamps, then the wisest plan would appear to be to lay down three engines and three dynamos, each capable of furnishing 250 lamps, one, of course, being for spare. As more lights are added a dynamo and engine capable of furnishing 500 lamps may be fixed, giving a perfectly safe supply of 750, or even 1,000, lights. Later on a set for 1,000 lamps may be added, and so on. The smaller engines and dynamos will be found very useful for night work, and will relieve the larger machines very considerably.

In running, the plan adopted should be always that two engines and dynamos do the work that is on, each if possible running under power, while a third one is running also, ready to be switched on in an instant; and there will, of course, be a constant watch upon the ampere and volt meters, and upon the dynamos and engines themselves, so that in case of any sudden trouble with any machine the work it is doing may be instantly thrown on to another one.

At the time when the heavy work of the day comes on all the engines and dynamos should be running, and each switched on in succession as the work shown by the ammeter calls for it; also, as the work drops off the larger machines should be stopped, and the smaller ones gradually settle down to their night's work.

(To be continued.)

AN ARMATURE-SAVING DEVICE.

One of the difficulties often encountered in electric motor practice is the severe strain put upon the machine in starting under full load. The armature is at rest, and receives the full rush of the current when least able to withstand

An Armature-Saving Device.

it. If it were possible to take up the load gradually, giving the armature a chance to protect itself by the counter E.M.F. developed, burnt out motors would be far fewer. The cut given herewith shows an ingenious plan, devised by Mr. E. H. Johnson, for the purpose of effecting this very useful end. The plan is a simple one. The armature does not drive the armature spindle directly, but by a somewhat flexible connection arranged in the following manner: The plates that form the armature core are mounted on a hollow cylinder, and through its centre passes the spindle, which runs loose in the end plates of the

COMPANIES' MEETINGS.

CITY AND SOUTH LONDON RAILWAY.

The twelfth ordinary general meeting of the City and South London Railway Company took place on Tuesday at Winchester House, Old Broad-street.

Mr. Charles G. Mott (the chairman of the Company), who presided, said that at the time of the last meeting one of the tunnels was incomplete, and they were then steadily driving it through the stratum of wet gravel at Stockwell. He was happy to say that the tunnel was completed without any mishap, and now that the whole of the tunnels were finished, they might well accord their best thanks to the engineers and contractors for the manner in which they had carried out the work. It was a work of exceptional difficulty, and it had been conducted throughout with exceptional success. No serious accident had occurred, and he believed there was hardly a record of so long a length of tunnel having been driven with so little accident or loss of life. The completion of the tunnel had been followed by the completion of the permanent way running through it. The rails were laid, and the electrical main cable for conducting the electricity, and the service conductor for the locomotives had also been laid throughout both the tunnels. The construction of the lifts had taken a much longer period than had been anticipated, for until these were finished they could not proceed with the final completion of many of the works connected with the stations and approaches. A great deal of the rolling stock was ready, and an engine and carriages had run by electrical power from one end of the line to the other at a speed greater than was required for the service. The Board were now busily engaged in arranging for the working of the line, and, as this was somewhat of a novelty, it was necessary that the staff should be well acquainted with their new duties before the line was opened to the public, which he hoped would shortly take place. The Bill for extending the line to Clapham had received the Royal assent, and by it the name of the Company had been changed to that of the City and South London Railway Company. He moved the adoption of the report.

Mr. S. Hanbury seconded the resolution, which was agreed to without comment.

At a special general meeting which followed, a resolution was agreed to converting the existing share capital of the Company into stock, in order to facilitate its transfer.

A resolution was also passed sanctioning the creation and issue of the new ordinary share capital.

The meeting closed with the usual vote of thanks.

CHILI TELEPHONE.

The first annual general meeting of the shareholders of the Chili Telephone Company, Limited, was held last Friday at Winchester House, Old Broad-street, Mr. R. R. Jackson presiding.

The Chairman, in moving the adoption of the report, said that no doubt many of them were anxious to know why the dividend they had to propose was not 6 per cent., as was anticipated by the prospectus of the Company. The fact was that when the prospectus was issued the rate of exchange was 26d. per dollar, but since that period the rate of exchange had fallen to 24d. per dollar. If the rate of exchange had continued all through at 26d. the earnings would have been close upon £1,000 more, and the dividend anticipated by the Directors would have been realised. There was, however, another difficulty with which the Directors had had to contend, and that was the difficulty with the dissentient shareholders resident in Chili with regard to the legalisation of the transfer. Negotiations were now pending, however, to settle the differences which he expected shortly would be brought to a close. The vendor company appointed the Company's manager in Chili to be the general manager of the vendor company, and since that appointment the business had been conducted without serious inconvenience; he therefore expected that the Company would make much greater progress in the future. He thought he might assure the shareholders that the prospects held out by the prospectus would be fully realised, as they had property of great value.

Mr. T. Greenwood seconded the motion, which was adopted.

The meeting then re-elected the retiring officers, after which a vote of thanks was accorded to the Chairman for presiding.

MAXIM-WESTON ELECTRIC.

A special meeting of this Company was held last week for the purpose of passing a winding-up resolution.

Mr. J. P. Gooding, who presided, stated that as the shareholders were not disposed to subscribe more capital to carry on the work of the Company, they could not go on. He thought they had sufficient to pay their liabilities. He moved: "That it has been proved to the satisfaction of the meeting that the Company cannot by reason of liabilities continue its business, and that it is advisable to wind up the same; and, accordingly, that the Company be wound up voluntarily."

After some discussion the resolution was agreed to.

Brazilian Submarine Telegraph Company.—The receipts for the week ended August 8 amounted to £4,863.

Western and Brazilian Telegraph Company, Limited.—The traffic receipts for the week ended August 8, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,761.

PROVISIONAL PATENTS, 1890.

AUGUST 5.

12171. **Improvements in electric motor mechanism.** Samuel Erastus Mower, 55, Chancery-lane, London. (Complete specification.)

12188. **Improvements in electrical switches.** William Paul Theerman, 18, Phœbe-street, Salford, Lancs.

12209. **Improvements in electric meters.** Heurtey René, 98, Rue d'Assas, Paris. (E. Meylan and W. Rechniewski, France.)

12221. **An improved apparatus for the measurement of electrical energy.** Henry Harris Lake, 45, Southampton-buildings, London. (Edward Weston, United States.) (Complete specification.)

12228. **Improvements in commutators for dynamo-electric machines.** James Watson Easton, 53, Chancery-lane, London. (Complete specification.)

12231. **Commutators for electrical machines.** Willis Willson Vail, 77, Chancery-lane, London. (Complete specification.)

12244. **Improvements in sockets for electric lamps.** Alfred Vincent Newton, 6, Bream's-buildings, London. (Alfred Swan, United States.)

12247. **Improvements in and relating to electric lamps or lighting apparatus.** Henry Harris Lake, 45, Southampton-buildings, London. (George Curtis Pyle, United States.) (Complete specification.)

AUGUST 6.

12330. **Improvements in thermo-electric batteries.** George Edward Gouraud, 191, Fleet-street, London. (Edward N. Dickerson, United States.)

AUGUST 7.

12337. **The indestructible electric filament used for incandescent electric light.** Conrad Herzog, 11, Queen Victoria-street, London.

12352. **Making electric contacts for ringing electric bells, and other purposes.** Arthur Henry Bagnold, Borstal Cottage, Rochester.

12381. **An improved device for facilitating the connection and disconnection of electrical conductors.** Alfred Lyster Shepard, 45, Southampton-buildings, London.

AUGUST 8.

12394. **Composition brushes for electric lighting.** William P. Odlum, The Elms, Portarlington.

12422. **An electric pendulum for firing ships' guns.** Johann Jenc, 22, Southampton-buildings, London. (Complete specification.)

12439. **Improvements in and relating to electric lamps or lighting apparatus.** Alfred Lyster Shepard, 45, Southampton-buildings, London.

12440. **Portable combination electrical testing set.** Arthur A. Day and Herbert John Dowsing, 4, Queen Victoria-street, London.

AUGUST 9.

12475. **Improvements in electrical smelting.** Eduard Taussig, 18, Buckingham-street, Strand, London.

12504. **Improvements in holders for incandescent electric lamps.** Edwin Percival Allam, 33, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1889.

13580. **Electric body belt.** Redfern. 6d.

13675. **Electrically lighting railway trains.** Langdon. 8d.

14380. **Telegraphy.** Allen and Brown. 8d.

14485. **Telephonic call apparatus.** Greenwood. 8d.

1890.

7867. **Electric motors.** Lake (The Giant Electric Motor Company). 8d.

9125. **Telephonic apparatus.** Kingsbury (The Western Electric Company.) 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	1¾
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	8

Lehigh Accumulator Cars.—A second 100 h.p. boiler and Westinghouse engine is now being installed for the Lehigh Passenger Railway Company to drive a 60,000-watt dynamo for their storage car system. The company has so far only received the batteries for four cars, and with these it is carrying from 50 to 110 passengers on each car at each trip.

The Electric Lamp for Neuralgia.—A writer in the *Medical Record* says that he has several times obtained much relief when suffering from facial neuralgia by applying to his face an incandescent electric light. He suggests that the lamp could also be used in poulticing, laying it over a flaxseed or other form of poultice, thus securing constant heat.

Division Vote Recorder.—Mr. Enos, who has invented a system of recording division votes, has asked for an appropriation of 60,000dols. to install the system in the American House of Representatives. In the session there have been 300 divisions, consuming 30 minutes each, adding up to 30 days lost in counting votes, of which the electric system would save 25 days.

Progress of Electricity in Germany.—A good idea of the development of the supply of electricity in Germany may be obtained from a glance at the following table of comparison, which is given as the number of ampere-hours supplied in Berlin by the Elektricitäts Werke during the month of August for the last five years :

Year.	1885	1886	1887	1888	1889
Ampere-hours.	1,462	5,875	7,825	13,290	22,000

Woodhouse and Rawson.—We are informed that Woodhouse and Rawson have been awarded a silver medal for their show at the Exhibition of Fire and Life Saving Apparatus now being held at Amsterdam. We notice that this company have now West-end offices at 16, Great George-street, and works at Union Foundry, Kidsgrove, and Strand Works, Chiswick, besides those at West Kensington, and Cornbrook, Manchester.

Telephone between Paris and Bordeaux.—The people of Bordeaux have long desired to be telephonically connected with Paris. As the result of an enquiry made by order of the French Postmaster-General, M. de Selves, the telegraph department have informed the Mayor of Bordeaux that the installation of a long-distance telephone line will be commenced as soon as the Municipal Council of that town will vote 450,000f. as representing its share of the necessary expenditure.

Sheffield Corporation.—A visit is arranged by the Parliamentary Committee of the Sheffield Corporation to the Bradford central electric station early in September, and the town clerk is to report on the steps necessary to obtain a provisional order. The Water Committee of the ame Corporation suggests the co-operation of any electrical engineer employed by the town to ascertain how far the numerous water wheels in the Rivelin Valley can be made available for the purposes in question.

Haslingden.—At the meeting of the Local Board of Haslingden, Lancs., last week, Mr. James Barlow gave notice that at next meeting he would move that the Board take into consideration the advisability of making application in next session of Parliament for the powers necessary to carry out the electric lighting of the district. This did not mean, he said, that they were going to carry out the powers asked for, but in order to prevent other people making application for those powers.

Electric Ventilators in Paris.—A large number of enquiries have been made during the recent hot weather in Paris for electric ventilating fans. M. Vernes, the able engineer of the Continental Edison Company, in his visit to the United States was struck with the usefulness of these fans, and has been doing his best to induce the Parisians to adopt them. It has been found well to allow the incoming air to pass over iced water, in which case the coolest and healthiest conditions are realised.

Harrogate.—The quarterly meeting of the Harrogate Town Council was held last week. A number of companies having given notice to the Corporation that they would seek powers for the purpose of lighting the town with electricity, the town clerk reported that the notices were in the hands of the borough solicitor, who was instructed to take all necessary steps with regard to the same in order to prevent the companies obtaining the powers which the Corporation hope in the near future to obtain themselves.

Fire at the Edison-Swan Factory.—An alarming outbreak of fire occurred on Tuesday morning at the Edison-Swan Electric Lamp Works, at Ponder's-end. It originated in the girls' workroom, which speedily became a mass of flames. Fortunately all the hands—numbering several hundreds—escaped without injury. The company's own fire-extinguishing apparatus, supplemented by that of neighbouring factories, did good service, and prevented what at one time threatened to be the destruction of the whole works.

Traction Cells.—We read that Mr. J. K. Pumpelly, of the Pumpelly Storage Battery and Electric Motor Co., is now manufacturing a cell in which the electrolyte is absorbed by a special cellulose fibre which is placed in it between the plates and filling it up. The evaporation of the electrolyte is thereby greatly decreased and the resistance of the cell is not materially increased. The E.M.F. also remains remarkably constant during the whole duration of the discharge. It is impossible for the acid to splash out, and the battery is stated to be admirably adapted for tramcar service.

Recutting Old Files.—The method suggested some time ago for the electric recutting of old files has on the recommendation of a Swiss engineer, M. Personne, of Neufchatel, been adopted by the Minister of War. This method, it will be remembered, consists simply in placing the old and worn-out files in a vessel containing acidulated water along with some plates of carbon, and then closing the circuit of the battery thus formed with short lengths of wire. Bubbles of air form and protect the teeth, while the rest of the metal is undercut. The process is simple, costless, and within the reach of any ordinary workman.

Private House Lighting.—The lighting of the Manor House, near Twyford, has just been completed for W. L. Beale, Esq. The installation consists of an 8 h.p. Priestman's oil engine, Crompton dynamo, and 53 E.P.S. cells, with about 120 incandescent lamps, and shortly the current will be utilised to pump water for the house. It is hardly necessary to say that the light gives the greatest satisfaction. The work of the installation was carried out by Mr. W. V. Scott, under the instructions of Mr. B. R. Beale, of Messrs. Crompton and Co., Limited.

Electric Subways in Paris.—A new company has been formed in Paris under the title of Societé Parisienne de Force et d'Eclairage. The managing director of the

dynamos of a total capacity of 425 kilowatts, or 993·5 h.p. The motive force was supplied partly by steam engines and partly by gas-engines. The installations have been carried out principally by the firms of Krizik, Waldek and Wagner, Siemens and Halske, Brückner, Ross, Ganz and Co., and Deckert and Homolka. Of the engines, 229·5 h.p., or 23 per cent., are gas-engines. The electric lighting of the theatre, recently substituted for petroleum, comprises four dynamos, of a total capacity of 116 kilowatts. This increases the number of incandescent lamps by 1,576, and the motive power by 190 h.p.

"The Electrophonoscope."—The American electrical journals just to hand are (some of them) making very merry over the discomfiture of a large part of the daily press and one, at least, of our electrical press—not to speak of the French papers—with reference to that huge scientific joke the "electrophonoscope." Those that don't make merry, of course, are of them that were taken in. Prof. Hughes naturally expected some people to be gulled, but even he, in his enjoyment of the scene on the Post Office Jubilee night, hardly appreciated the world-wide effect of his harmless playing on the credulity of the world with regard to that mysterious and powerful nothing we call "electricity," to whose account, in the popular mind, is laid all species of things—from an abdominal pain to the supposed hauntings of departed spirits. We are still, from time to time, asked for particulars of this wonderful invention, for the press have many of them not dared to retract. Those who still wish to enlighten their friends are referred to our issue of July 4.

Electric Power Rates.—We have always maintained that eventually the use for electric current will be greater for the distribution of power than even for light. That this is likely to be so, the extension of power distribution in America, where central supply stations have been erected more quickly than over here, is practical proof. The extension of the motor business will depend, naturally, largely upon the rates of supply, and it is interesting to note the rates which have recently been scheduled by the Brush Company of Baltimore, "after a very careful consideration." The prices are to range practically as follows:

H.P.	£	s.	d.	H.P.	£	s.	d.
$\frac{1}{10}$	0	10	0	4	5	5	0
$\frac{1}{4}$	0	12	0	5	6	2	0
$\frac{1}{2}$	1	0	0	6	6	15	0
1	2	0	0	8	8	10	0
2	3	5	0	10	10	0	0
3	4	5	0				

There are 375 motors at present at work in Baltimore, representing over 200 h.p. of daily consumption of current. With the present rates, which took effect on July 1, a large increase in motor business is expected.

As Gold or Silver.—We observe that the president of the French Gas Society, M. de Treust, is reported to have said, in his introductory words to the last meeting, that on looking around the great exhibition at Paris at the white electric light and warm yellow gas light, he felt reminded of silver and gold, and of the relative value of these and of the ratio of their relative dividends. The figure of speech is a pretty one, and M. de Treust is welcome to it if he finds it consolatory under the present rate of progress of the white light over the "warm" (we term it "dingy") yellow light of gas. It may be remarked, however, in this connection, contrary to what was at first anticipated by electrical engineers, that yellow—*i.e.*, incandescent-lamps in the aggregate do pay better than white or arc lamps; also that the blue-white light of the arc, as it approximates to golden by the adoption of the vaselined carbon, may be expected to yield higher dividends. So that the pretty figure of speech holds good, we may say, among the "illuminant of the future," as well as (for the moment) with our friend the warm and dingy gas.

Electricity from Tides.—A correspondent to the daily papers, signing himself "Tidal Power," says: "I may say that some years ago I made a large number of experiments on a small scale to see if it was not possible to invent a plan by which the rise and fall of the tides could be used to drive motors continuously during the 24 hours. I succeeded beyond my expectations. I then went into the cost of doing this, to obtain a given horse-power as compared with steam-engines and boilers, when I found that the prices were very near alike. But the saving ever after in favour of the tidal plan would be very great. For instance, the cost of looking after the tidal machinery would be but trifling, as one man for the day and another for the night would be sufficient to see to hundreds of horse-power, as the machinery could be made nearly self-acting, whilst the wear and tear of machinery would be very moderate. Compare this with steam-engines and boilers, and the saving will be found to be very great year by year. There are hundreds of places around the coasts of the United Kingdom and on tidal rivers where this plan could be carried out, and the power obtained could be transmitted to long distances by any of the well-known means used for such purposes."

Buffalo Bill in Berlin.—A large electric lighting plant has been put down almost at a moment's notice for the Buffalo Bill show in Berlin, by the firm of Erfurth and Seinell. As the German authorities do not permit of the use of high-tension alternating currents for public shows the Buffalo Bill Wild West Company was obliged to leave its own removable lighting plant at Paris, and subsequently invited tenders for the electric lighting of their show (about 60,000 square yards area), in conformity with the very severe rules established by the German authorities for electric lighting. The above-named electrical firm undertook the difficult task to put down the plant according to these rules within eight days; the work was begun on the 19th of July and was successfully finished in seven days eight and a half hours. It consists of 150 arc lamps, with reflectors, of 1,500 c.p. each, suspended from high posts, 50 glow lamps of 25 c.p. each, and a search-light projector of 45 amperes, together with 20,500 yards of wire and cables and 1,500 insulators; a special machine-house had to be erected for four boilers of 25 h.p. each, and four 200-volt dynamos. The plant runs to the highest satisfaction of the Americans, who scarcely thought such a rapid work possible elsewhere than in their own country.

Ferranti Mains.—Those who are curious to do so, may now see the Ferranti mains being laid within easy distance of the City. Some few hundred yards down the Blackfriars-road the road is up and a goodly row of these Titans among mains are being laid side by side. The roadway is taken up and trenched some 4ft. deep, and in this trough eight lines or four pairs of mains, in flexible steel pipes, 2in. diameter, are run along the ground. The process of jointing may be seen in operation. Each pair of mains is then boxed within tarred wood slips, and melted bitumen poured around and upon them, and then the gravel and soil shovelled in on top, with the granite setts laid again properly for the roadway. It is interesting to

watch these slender tubes, and to calculate the gigantic force they are intended to distribute. Suppose, say, 100 amperes are sent along one main at 10,000 volts, this is 100,000 watts, and this energy, as a very little calculation will show, dividing by the well-known 746 (watts per h.p.), give somewhere over 1,300 h.p. to be sent along the tube. In a short while the line will be along Stamford-street and on to Charing Cross, when the full pressure will be turned on, though a part only of the installation now running will at first be supplied by the underground mains, which will be put into use gradually and one after the other, as the tests show they are working in good order.

Overthrow of the German Telephone Monopoly. Until lately the German Post Office arrogated to itself the sole right of erecting or licensing private telephone installations, thus prohibiting the development of a most convenient means of communication and excluding the legitimate industry from a branch which ought to be its domain. The well-known telephone manufacturing company, Actien Gesellschaft Mix and Genest, Berlin (whose branch in London is the International Electric Co., 34, Aldermanbury, E.C.), determined on principle, and in the interests of the telephone world at large, to try the point in a court of law. To this effect they brought an action against the German Government (Reichsfiskus) claiming that: "It (the German Post Office) had no right to restrain or prohibit the plaintiffs to erect and maintain private telephone installations (*a*) between buildings belonging to the same landlord but situated at a distance from each other and separated by property of other landowners, or by public roads or otherwise; (*b*) between property belonging to different landlords—*i.e.*, from one part of a city to another." This claim was decided on the 10th July in the Royal High Court of Justice (Königliches Landgericht I) of Berlin, entirely in favour of the plaintiffs, thus putting an end to a state of things which has lasted too long to the disadvantage of all those interested in this daily progressing industry.

Primary Battery Lighting.—We have received an interesting reply to our enquiry last week, as to electric lighting by means of primary batteries, from Messrs. A. Schanschieff and Co. They state that they are now supplying batteries arranged for single lights and for small installations, and they give some particulars of the employment of the Schanschieff batteries, which we think will be interesting to our readers. They are at present fitting the batteries to railway carriages on the Paris, Lyons, and Mediterranean Railway. The French fire brigade are now using them, as also, by order of the French Government, are the powder magazines and the petroleum vessels. Several French and English mines have adopted the lamps. The Italian Government are using them for tent lighting and other purposes, and the Swedish Government for their artillery. The new Goubet torpedo boat, recently experimented upon by the French Government, is driven by this battery. Besides this important instance, there are several motors in this country in constant use driven by the Schanschieff battery. The battery is very simple, and is easily recharged by any person. It is used with every success for the purposes named, and the makers state they will be pleased to show any visitors who care to call at their works, 6, Appold-street, Finsbury, batteries of all sizes for either light or power. We are glad to find the Schanschieff battery asserting itself in actual practice as these facts serve to show, for this is the only real test of a battery, and its success, if continued in these directions, should lead to its more extensive adoption for small work where dynamo currents are not available.

Telpherage for Ireland.—A correspondent in Londonderry writes to us with reference to the employment of light electric railways or telpherage in Ireland—a subject, it may be remembered, though not directly referring to electrical systems, that has seriously occupied the attention of the present Government. Our correspondent considers that telpherage lines might be used for bringing to market from the remoter districts of Donegal parcels of farm produce which cannot now be marketed economically. Whilst in this district there is not sufficient traffic to support even a light railway, there is a pressing need of some ready means of reaching the market, especially with perishable goods; and were such means provided an enormous impulse would be given to small farming, dairy farming, and poultry raising, and other occupations of the peasantry. The mails, too, which are now carried at great expense by horse-cars and foot messengers, would be enormously expedited; and it is probable, thinks our correspondent, that a subvention would be obtainable from the Post Office in aid of any proposed telpherage line in Donegal. The only point upon which there is any doubt is that of the expense in working the system; and definite information, which must now be at the service of electrical engineers, should be laid before the public. The employment of water power, of which in this case there is plenty, would tend to minimise the cost of working. We shall be interested to see if this enquiry for a case, which *à priori* seems eminently suitable for the enterprise, will result in the establishment of telpherage lines in Ireland.

The Gordon Closed Conduit System.—Allusion has been made once or twice in these columns to a new closed conduit system for electric tramway traction, from which great things are expected—with what actual promise we are hardly in position as yet to say, as the trial line is not yet complete. Mr. Merryweather, of the fire-engine firm, has written to the public press, mentioning the fact that a line is being constructed at their works at Greenwich. The system in question is the invention of Mr. John Gordon, lately the manager of the Swan lamp factory in Germany, but who for the last eight months has given up his whole time to the development of his traction idea. We are unable, for patent right reasons, to describe the system fully, but we have been familiar for some months with the design, and it may be mentioned it is an ingenious method of charging underground conductors by means of a special system of automatic distributors, situated at considerable distances along the line, the construction of the line and conductor-rail being of the simplest and cheapest description. The system has been taken up by a small syndicate, consisting of City financiers and the gentlemen named. The system is simple, certainly ingenious, and undoubtedly novel; and having due regard to the enthusiasm of the energetic inventor, and the mechanical skill commanded by the syndicate, we should fancy it ought to be a decided step in the solution of the electric traction problem for towns. We believe that offers are already in negotiation for the installation, when proved workable, of the system in South America, the closed conduit to be laid through the crowded streets in the town (the car here to go slowly and pick up passengers) connected to an overhead system outside the town to the suburbs, where the speed might be increased up to 20 miles an hour. A system such as this would prove a very serious rival to the suburban steam railways

DYNAMO TESTING.

The subject of dynamo-electric machines is one of deep interest, whether looked at from a theoretical or practical point of view. From being the curiosity of 1866 it has developed, until in 1890 it is generally recognised as one of the most efficient pieces of machinery used by man, and the uses to which it has been applied are daily increasing.

Under these circumstances an enquiry into the principles and methods by which dynamos are tested and their efficiency determined will be both useful and instructive.

The function of a dynamo is well known—viz., that it is a machine by means of which we transform mechanical energy into electrical energy by means of the rotation of a conductor placed in a magnetic field in such a position that during its rotation the number of magnetic lines of force passing through it is altered.

For our present purpose it will be sufficient to consider only continuous-current machines, as the variations to be made in these methods when applied to alternate-current ones are best considered for each special case.

The sources of loss in a dynamo are mainly the following:

1. Friction of the armature spindle in its bearings:
2. The resistance of the air to the rotation of the armature.
3. Energy spent in overcoming the electrical resistance of the field-magnet coils.
4. Energy spent in heating the armature conductors.
5. Eddy or Foucault currents in either the field-magnets, armature core, or possibly the armature conductors.
6. Loss due to the leakage of magnetism.

The terms electrical, commercial, and mechanical efficiency may be thus explained:

Electrical Efficiency.—The ratio of useful external electrical work done to the total amount of electrical energy generated by the machine. This varies with the load on the machine; for a series-wound dynamo we may express it thus:

$$\frac{C_2 R_{Ex}}{C_2 R_{Ex} + C_2 R_a + C_2 R_M}$$

where R_{Ex} is the resistance of the external circuit, R_a the resistance of the armature, and R_M the resistance of the field-magnet coils. Always supposing we do not allow our armature and field-magnet coils to get so hot as to materially alter in resistance; R_a and R_M remain constants, but the energy spent upon them varies not directly with the load, but in proportion to the product of R_a and R_M (constants) into the square of the amount of current flowing, which is the factor usually varying with the load.

Commercial Efficiency.—The ratio of useful external electrical work done to the total amount of mechanical energy imparted to the dynamo. This also varies with the load.

Mechanical Efficiency.—The factor of conversion of the machine from mechanical energy into electrical energy.

It will be noticed that in comparing the efficiencies of dynamos it is necessary to take into account all the conditions under which that efficiency is calculated; it is usual to compare tests made when machines are working at full load, as then they are under their most favourable conditions.

In the event of a dynamo suddenly falling off in output owing to failure of insulation, it is easy by means of a battery and detector to find out any fault due to this cause, and afterwards to localise it by disconnecting the magnet coils from the armature and testing each separately.

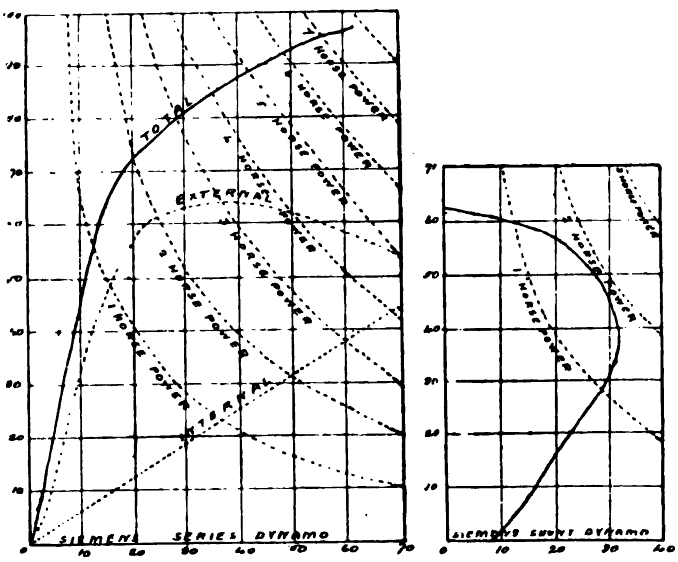
The resistance of the field magnets may be tested, if required, with a Wheatstone bridge, Leclanché cell, and galvanometer, and the resistance of the armature, which, of course, is very low, either in the same manner, or by allowing a current to flow through it from brush to brush, and then through a platinoid resistance placed in series with it, and noting with a voltmeter the fall of potential between the terminals of the resistance, and also between the brushes of the armature. The resistance of the platinoid is known; the fall of potential, or E.M.F., is also known, $\frac{E}{R} = C$; which might, if preferred, have been directly measured with an ammeter. The fall of potential between the brushes is known, $\frac{E}{C} = R$, which is what we require—the resistance of the armature.

The insulation resistance of the dynamo may be obtained by comparing the deflections on a high-resistance galvanometer, obtained first through the galvanometer, and, say, a resistance of a megohm; and, second, testing through the galvanometer and insulation.

Characteristic Curves are extremely useful in determining the fitness of a dynamo for any special work. These—first introduced by Dr. Hopkinson, in a paper read before the Institution of Mechanical Engineers in 1879—are very instructive, and may be obtained by running your dynamo at a constant speed, varying the load, and noting the current and E.M.F. at terminals in each case. Now, plot out on squared paper the currents as distances along a horizontal line, and, using the same scale, the E.M.F. as distances up the vertical line, drawn from the point of origin of the previous one. It is usual to use such a scale that the distance on the vertical line representing a volt is equal to the distance along the horizontal one representing one ampere.

For a series-wound dynamo, if we join the points we thus obtain, we get a curve similar to that marked "external" in Fig. 1. If we multiply the current in each case by the internal resistance of the dynamo, and add these quantities to the spaces representing volts, we get a new curve marked "total," which represents the total amount of electrical work done by the dynamo.

Characteristic Curves.



Amperes. Amperes.

FIGS. 1 AND 2.

For a shunt-wound machine the external characteristic is different, as shown in Fig. 2, the sudden drop in E.M.F. after a certain current is taken out being due to the diminution of strength of the magnetic field owing to the smaller amount of current flowing through the shunt. The internal characteristic of a shunt-wound dynamo—*i.e.*, the characteristic when no external current is being used, and only the magnetising coils are in circuit—is, of course, similar to that of a series-wound dynamo. The work done by a dynamo may be expressed electrically as the product of E.M.F. and C—*i.e.*, we may represent it as the area of a rectangle, of which two of the adjacent sides are those parts representing E.M.F. and current. It is therefore possible, as pointed out by Prof. S. P. Thompson, to obtain a number of points which would be the corners of rectangles having the same area, and to draw curves joining these points. Representing volts as ordinates, and amperes as abscissæ, the area C E = watts, and all points having an area of 746 may be taken to represent 1 h.p. In Figs. 1 and 2 horse-power lines are shown.

By Ohm's law R in ohms $= \frac{\text{E.M.F. in volts}}{\text{C in amperes}}$.

Sine of angle D A C $= \frac{\text{D C}}{\text{A D}}$.

Cosine of angle D A C $= \frac{\text{A C}}{\text{A D}}$.

Tangent of angle D A C $= \frac{\text{D C}}{\text{D A}} = \frac{\text{sine}}{\text{cosine}}$.

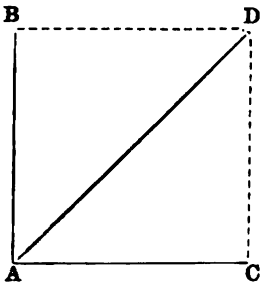


Fig. 3.

Therefore, taking in the rectangle, A B C D, the line A B to represent the E.M.F. in volts, and A C to represent the current in amperes, the tangent of the angle D A C represents the resistance expressed in ohms.

In Fig. 1, where a line marked internal is shown, it is easy to calculate the internal resistance of the machine, for the tangent of the angle gives it to us in ohms. Thus, knowing the characteristic curves of dynamos enables us to select those most suitable for any work we may have to do, and therefore to work them under the most economical conditions.

Previous to 1885, when dynamos were tested, transmission dynamometers were employed to measure the power given to the machine. Of these there were various forms: that designed by Mr. F. J. Smith being very ingenious. The error with these instruments was very great, reaching in some cases up to 3 per cent. of the amount measured. Confidence in these results was, of course, impossible.

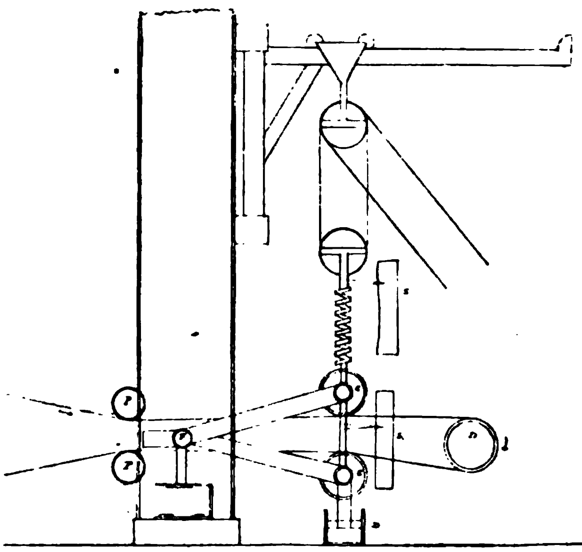


Fig. 4.

In November, 1885, Dr. Hopkinson suggested, and in February, 1886, showed the practicability of a method of testing in which the dynamometer error was reduced to a minimum. He took two dynamos of the same size and output, coupled their shafts rigidly together, and so connected them electrically that one machine ran as a dynamo, and the current it generated ran the other as a motor, which in its turn helped to drive the dynamo. It is obvious that if all the current generated by G, Fig. 4, is passed through M (excepting the small amounts necessary for field excitation in the two cases), and all the work done by the motor is to help to drive the dynamo, we shall only have to supply just sufficient external energy to balance the loss in the two machines. This amount was measured with a dynamometer, the error, owing to the small amount of power transmitted, bears such a small ratio to the total power used in the experiment that it is practically negligible.

Fig. 4 shows the form of Siemens dynamometer used in the tests. Its action depends on the fact that the pull on the lower part of a belt transmitting power is proportional to the load. The belt which supplies power to the dynamos passes between the pulleys, G C, which are pivoted on the fulcrum, F. Any pull alters the length of the spring, G_1, and the amount of lengthening is measured upon the scale, S_1. The upper pointer is adjusted to zero before starting, so as to secure similar conditions.

(To be concluded.)

THE HISTORY OF A PROVISIONAL ORDER FOR SUPPLY OF ELECTRICITY.

Mr. G. Offor sends the following communication to the *Times*:

"Sir,—As an example of the legislative difficulties in the way of supplying the public with electricity the following statement of facts will, I hope, encourage suggestions through your columns for relieving the new industry from the impediments under which it suffers from the application of the laws relating to it.

"My company, being desirous of supplying a metropolitan suburb with electricity, selected as a suitable area the Crystal Palace and the residential neighbourhood which has grown up around it.

"Our first obligation was to give notice to the local authorities of our intention to apply to the Board of Trade for the grant of a provisional order, and, upon consulting the map, we found that, owing to the peculiar geographical position of the district, we had to deal with the Local Boards of Lewisham and Beckenham, in the county of Kent, the parishes of Camberwell and Lambeth, and the borough of Croydon, all in the county of Surrey, besides the London County Council, having jurisdiction over an area called the county of London, which includes Lewisham, excludes Beckenham, includes Camberwell and Lambeth, but excludes Croydon, the Crystal Palace itself being in all three counties (Kent, Surrey, and the county of London), and the borough of Croydon reaching to within 80ft. of the Crystal Palace.

"On July 1, 1889, I gave notice to all these local authorities in accordance with rules framed by the Board of Trade. In November following advertisements had to be inserted in the *London Gazette*, and a paper circulating in the district to be supplied containing a general description of the proposed works, area of supply, names of streets in, over, or along which electric lines or works might be placed, and many other details, and on or before the 30th of that month a copy of the advertisement and map had to be deposited with the local authorities and Board of Trade, and also with the clerks of the peace for each county.

"On the 21st of December the next formality was complied with—viz., lodging a memorial with the Board of Trade praying for the grant of the required powers—and with this memorial were deposited six copies of a draft of the proposed provisional order in detail, a formidable document, covering some 50 folio pages of print. Copies of this draft were sold at a shop within the area of supply and furnished to all the local authorities, and compliance with all the above formalities was subsequently proved at the Board of Trade.

"Thus far all was plain sailing, but with the issue of the draft order came objections from local authorities, the local gas company, railway companies, and others, and my company was occupied for several weeks in negotiations for meeting the oppositions to the grant of the order. In one case the reasons for opposition were about as definite as the celebrated lines

"'I do not like thee, Dr. Fell,
The reason why I cannot tell.'

the following being copy of the notice of opposition, sent to the Board of Trade, with which we had to deal:

"'Board of Trade, Session 1890.

"'Crystal Palace and District Electric Lighting (Provisional Order).

"'The Lewisham District Board of Works have not consented and do not consent to the grant of this order.

"'Dated this 31st day of January, 1890.

"'Edward Wright, clerk to the said Board.

"'Dyson and Co., 24, Parliament-street, Westminster, S.W., parliamentary agents.'

"The parish of Camberwell alone agreed at once to the order being granted. Lambeth ultimately assented upon

the inclusion of part of the parish in the area to be supplied within two years, but all the other authorities opposed, with the main object of obtaining different terms for purchasing the undertaking than those provided for by the Electric Lighting Act of 1882 as amended in 1888.

"Section 4 of the Board of Trade Proofs requires evidence that the consent of every local authority has been obtained to the grant of the order, and although under the Act of Parliament the Board of Trade can dispense with such consent if they consider that it is unreasonably withheld, no such power was exercised, and my company was constrained to make terms with Croydon, Beckenham, and Lewisham (ultimately embodied in the order as applicable to all the local authorities, although not required by Camberwell or Lambeth) for giving them the option of purchasing the undertaking upon certain terms within their respective districts at the end of seven and within 15 years, instead of waiting 42 years, as prescribed in the Act of 1888.

"Having at last settled the terms of the provisional order, it was granted by the Board of Trade subject to confirmation by Parliament, and the sequel will show that this proviso was not a mere formality, for the whole of our work was placed in jeopardy by the action of the London County Council, who lodged a petition against it in the House of Commons, notwithstanding the grant of the order having been made with the assent of every local authority having any actual control over the thoroughfares in the proposed area of supply.

"To contest the order before committees of both Houses of Parliament at the end of July or beginning of August was not only to add to the heavy expenses already incurred, but to risk not getting the Bill through Parliament this session and the consequent necessity for commencing *de novo*, losing another year, or abandoning the enterprise. We therefore negotiated terms with the London County Council, and they ultimately consented to withdraw their opposition upon our eliminating that part of Croydon which was included in the area of supply, thus preventing our supplying the houses on one side of Westow-hill, which is in Croydon, while able to supply those on the opposite side of the road, which are in Lambeth, and preventing our supplying houses in Croydon which are within about 100ft. of the Crystal Palace. The reason originally given by the London County Council for their opposition was their desire to limit the undertaking to an area within the county of London, but when they agreed to the inclusion of Beckenham, which is outside the new county, there was no reason why they should interfere with the arrangements made with the Corporation of Croydon.

"The provisional order has at length received the Royal assent and is now an Act of Parliament after more than 13 months being occupied in obtaining power to supply the residents in a compact district who may desire to have the electric light.

"Surely some modifications in the law are necessary in order to save the waste of time and money now involved in an application for powers to disturb in a very slight degree the thoroughfares through which it is required to place electric conductors. The confirmation by Parliament of arrangements agreed to by the Board of Trade in consultation with the local authorities concerned certainly might be dispensed with. This would shorten the time, prevent vexatious opposition, and save some expense in promoting the new industry, which has quite enough difficulties to contend with without being hampered by so much legislation."

ELECTRIC TRACTION AT SOUTHEND.

Electrical traction in this country is making slow but sure progress. Electrical engineers were handicapped by the fact that local authorities, as a rule, opposed the use of overhead conductors, which have contributed so greatly to the popularity and consequent success of electrical traction in America and on the Continent. Engineers on this side have been therefore confined to the development of underground systems of conductors, or to the use of accumulators carried by the cars themselves. In neither of the latter two cases has sufficient success been hitherto attained in England to sufficiently attract public attention to the manifold advantages which any system of electrical haulage presents.

It is therefore with pleasure that we notice an extremely successful addition to the few electrical tramways now being worked in this country. The Southend Local Board, which is a very enterprising public body, and has introduced a large number of local improvements, with a view of further popularising the already rapidly increasing town of Southend, has recently constructed a new iron pier, costing about £80,000, to replace the old wooden pier, which was itself one of the most remarkable constructions of the kind in the country, being a mile and a quarter long, and fitted with a horse tramway. The Board decided to replace horse traction on the new pier by an electric tramway, and, after specifications had been issued, Messrs. Crompton secured the contract in public competition. One feature of this contract was the speed at which it had to be carried out—namely, that a portion of the work, amounting to three-quarters of a mile, fitted with an electrical tramcar, with all the plant as well as the lighting of the pier, should be completely set to work on the day previous to the August Bank Holiday in order that the Bank Holiday traffic might be secured for the new tramway. This only gave the contractors six weeks in which to lay the track and supply all the generating machinery, and build the car, motor, etc. By good engineering, organisation, and a willing staff, the contractors were fortunate enough to succeed in carrying out their contract one day within the time, and it can be readily understood what extreme credit is due to everyone concerned, particularly to Mr. Chamen, the chief of their outdoor staff, and to Mr. Scott Moncrieff, who is resident at Southend, for the extraordinary rapidity with which the work has been carried out without a hitch or alteration in the original design.

The generating plant consists of a horizontal compound engine by Davey-Paxman, supplied with steam by a boiler of locomotive type. Both are extremely favourable examples of the highly economical and extremely efficient class of steam-engine that this well-known firm is now turning out. This engine drives a Crompton compound dynamo of their standard type, having an output of up to 150 amperes by 200 volts at the terminals, and having a commercial efficiency exceeding 90 per cent. The electrical energy is conducted from the engine-room by insulated cables carried along the pier to the commencement of the car track, and from thence to the end of the pier. Messrs. Crompton determined to use their stock pattern flat-strip copper conductor that they have been using for the past four years in the streets of London, the whole of the supports, insulators, and straining gear being taken from the stock, and identical in all respects with those they have used in upwards of 30 miles of streets in Belgravia, Kensington, and Notting Hill. The strip used in this instance is 1in. wide by ·134in. thick, and is supported at intervals of 15 yards by vertical insulators, and strained in lengths of 85 yards by straining gear having volute springs to compensate for expansion due to differences of temperature, the insulators in both cases being the stock pattern used for street mains.

The track consists of a pair of vignoles rails, 3ft. 6in. gauge, the strip conductor being laid about 1ft. distant from one of the rails and 1in. below the level of the rail tops. The rails themselves are used for the return. The car was built for Messrs. Crompton's order by Messrs. Kerr, Stuart, and Co., and the motor is a stock pattern Crompton dynamo, the speed being reduced as 3 to 1 by simple spur gearing. The motor is fixed below the bottom of the car, and access can be given to it either by bringing the car over the pit or by lifting a trap in the flooring. The car is driven from either end, and the means of regulation are extremely simple, a pair of handles, one for reversing and one for starting, with the ordinary brake wheel in front of the driver, being all that is required.

The maximum speed of the car is 20 miles an hour, but in ordinary running the speed is kept down to about 12 to 14 miles an hour, so that the journey along the pier, which used to occupy previously about 15 minutes, is now performed in three to four minutes. The contact apparatus for taking the current through the strip consists of rubbing

shoes especially designed for this purpose by Mr. Chamen, and which appear to act very perfectly and without apparently causing any wear to the surface of the copper strip.

An official trial was made by Dr. Hopkinson, consulting engineer to the Local Board, on the 30th of July. He

Crompton Dynamo for generating current

expressed himself completely satisfied with the workmanlike manner and extreme celerity in which the work has been carried out, and the members of the Local Board and the townspeople generally have over and over again

Car travelling at 15 miles an hour.

expressed their extreme satisfaction with the unexpectedly rapid completion of the work and its great success. The day following the official trial the car was handed over to the Local Board for regular running, and has been running ever since without breakage or interruption of any kind.

On Bank Holiday the car was overloaded every journey, and the takings amounted to upwards of £40, and ever since that day the takings have been heavy.

It is evident from this that the Southend authorities have made a good investment of the local funds in introducing this electrical tramway. The horse-power absorbed in driving a loaded car at full speed appears to be remarkably small, in fact, considerably below what Messrs. Crompton estimated it would be.

End view of car three-quarter mile up pier.

As soon as the pressure of public traffic of this season is over Messrs. Crompton hope to be able to make a set of experiments to show what is the real tractive force required on this class of electrical railway, and intend to make these results public.

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UNION IS STRENGTH.

One of the earliest recollections of a schoolboy is the fable of the old farmer and his sons. Once upon a time—so commence all fables—an old farmer at the point of death called his sons together, and pointing to a bundle of sticks asked them in turn to break the bundle. Of course the fable tells us they failed, but succeeded when the sticks were taken out of the bundle and acted upon separately. The moral of the fable which the old farmer wished by this means to impress upon his sons is given in the motto at the head of this article.

Where, however, is the analogy between the old farmer's action and anything electrical? Not long since a syndicate or company was formed to see what could be done, legitimately or otherwise, with the claims of Lane Fox as embodied in patents granted in 1878. Letters cautioning people using certain apparatus have been sent by the Lane Fox Syndicate, conveying the information that by such use patents are being infringed, and unless a pecuniary solatium is forthcoming legal proceedings will be commenced, and then—who knows? A good many wideawake people thought and think the move simply a game of brag—a move, however, which might have turned up trumps, but which seems destined to prove abortive. Men have become heartily sick of electrical litigation, and almost prefer to cave in to threats rather than to fight for their rights, or rather what they and their advisers honestly believe to be their rights.

Preferably to being blackmailed, a combination has been started whereby any action commenced can be fought to the bitter end with the least trouble and expense. If the Lane Fox Syndicate's contention is correct, then everyone using the apparatus or system must pay a royalty, and the amount of the royalty will be no small matter to an industry where competition has already proved so keen that profits are difficult to obtain. If the opinions of Sir F. Bramwell, Mr. Swinburne, and Mr. Kapp, as mentioned in the letter given elsewhere, are correct, and these opinions are emphatically those of scores of other electrical engineers, the pretensions of the Lane Fox Syndicate are as invertebrate as they can possibly be. The combination to oppose these claims will prevent one obvious method of procedure. The plan of attack would undoubtedly have been to have selected the weakest opponent—by weakest, we mean the one with the shortest purse, to have cowed him by legal expenses, and have got a small royalty from him rather than a fight. A successful outpost affair of this kind would have immensely strengthened the hands of the syndicate, and proceeding to the next weakest the claim would have been strengthened and he less satisfied to stand out for his own belief. Now the weakest is in the same position as the strongest, for we have reason to believe the appeal

has been successful, and that a strong combination has been formed to protect what may in this case undoubtedly be called common interests.

The probable effect of the combination will be to materially alter the proceedings of the Lane Fox Syndicate. It is possible that nothing more will be heard of claims that to most of us are unsubstantial and unsustainable. Still no effort should be spared to perfect the combination, for the result of a patent action is not to be foretold. We should not be surprised to find a patent granted for a combination of a box, one end of which may be affixed to one or more wheels, with handles placed at the corners of the opposite side, while the four lower corners are supported by four legs, nor should we be surprised to find this claim for a wheelbarrow held to be legal. In the majority of instances a patent is not worth the paper it is printed upon, but its validity is unquestioned because uncontested; in other instances patents are held to be valid which contain nothing new, or contain some combination which anyone would use if requested to carry out certain work. However, the value of a patent is just what can be got out of it. Railing against the method of granting patents, or the uncertainty of the law concerning them, does no good. In the case under consideration the "cons" are putting themselves in a position to withstand the attack of the "pros," and our sympathies being altogether in favour of the former, as well as believing them to be altogether in the right, we welcome the combination and trust it will have the support of every individual and firm throughout the industry.

TROUBLES OVER ORDERS.

Job, we are informed, was a patient man, but whether his patience would have stood the test of modern red-tapism, coupled with officious bumbledom, is a question that may be relegated for solution to the sphinx. At any rate, Mr. G. Offor's letter to the *Times*, given elsewhere, shows that the troubles and trials of those who desire to obtain provisional orders are by no means imaginary. In the sweet by-and-by we shall get from balance-sheets the cost of these labours, and no doubt many men will be astonished to find how large a percentage of the cost of a small central station goes to fulfil the demands of red-tape. And we are a practical nation! Old womanish legislation—which Lord Salisbury tells us our ancestors would have made short work with, and our descendants will cavalierly push aside—seems now, however, to be most fashionable. You may lay your mains down this street, and you may supply current to that side, but you must not supply current to this side, because the immaculate L. C. C. says, Nay. Surely lawyers have the making of laws, and thereby reserve to themselves the handling of as much money as possible, for all these compliances with standing orders, negotiations with authorities, in some way or other turn to the profit of the lawyers. Mr. Offor cannot see the reason of the L. C. C.'s opposition under the circumstances stated, but he forgets that opposition is generally held to be unanswerable—to those not on the side of the opposition. Moral and advice: Light both sides of the street if you can get customers, and if you don't make a fuss about it, probably the L. C. C. will not trouble itself.

THE CITY LIGHTING.

This week or next the Royal assent is expected to be given to the Bill which confirms the two provisional orders granted by the Board of Trade for the electric lighting of the City of London. This Bill, introduced first in the House of Lords, was, on Friday last, passed by the Unopposed Bill Committee in the House of Commons. It confers on the Brush Electrical Engineering Company and on the Laing, Wharton, and Down Construction Syndicate the concession to publicly light a large portion of the City of London, and the sole right, each in their district, to furnish current for private lighting. Roughly speaking, the eastern district of the City is given to the Laing-Wharton Syndicate, and that west of Mansion House and Moorgate-street to the Brush Company. The Brush Company are to furnish 138 public arc lamps and 302 glow lamps. The Laing-Wharton Syndicate furnish 233 arc lamps and 307 glow lamps. The price to be paid to these companies is £26 per arc lamp and £10 or £5 each glow lamp of 200 or 100 watts (say 50 and 30 c.p.) respectively. The work is to be commenced within nine months of the 19th of May—*i.e.*, before 19th Feb., 1891—and to be carried on diligently and completed within 21 calendar months from the first-mentioned date. The high-pressure series system will be used for the arc lamps, and high-pressure alternate currents with transformers for the private lighting. It is understood that the generating stations will be outside the City area.

KEEPING THE BALL ROLLING.

Major Flood Page, in a letter to yesterday's *Times*, continues the crusade against the multiplicity of fire rules. He points out that there are 33 offices, and he understands that:

(*a*) Ten offices use the Phœnix rules.
(*b*) Six „ „ „ Institution „
(*c*) Ten „ have each their own special rules.
(*d*) Seven „ have no special rules, but deal with each case as it arises.

Seven of the above offices send out a list of questions which must be answered by those who wish to have the electric light in their houses.

The upshot of Major Flood Page's communication is to suggest the general use of the Phœnix rules,

especially as all the other rules are more or less based upon these rules, differing in minor details, not in principle. It is explained that rules alone are not sufficient, but, in addition, there must be rigid inspection. It will be seen that the general tendency of this letter to the *Times* accords with the views that have been expressed in these columns, and we have no doubt these views would prevail could the personal question be put on one side by the officials of the companies in the minority.

THE EDINBURGH EXHIBITION.—XIII.

The exhibit of the Electrical Engineering Corporation, Limited, includes Statter and Brunton constant-current magnets; these are of forged "magnet iron," and are machined all over. The pole-pieces are of cast iron of ample section, and the joint between the wrought and cast iron is very carefully fitted.

The insulation resistance of these machines is very high, usually about 10 megohms for the whole machine, and is obtained by the employment of mica. It is, therefore, a permanently high magnetic resistance, and does not depend upon paper soaked with shellac, which, though giving a very high insulation when dry, readily absorbs moisture, and so loses its insulating properties.

The armature is built of Swedish charcoal sheet, and is well ventilated; the winding is driven directly from the spindle and very firmly held in order to withstand the sudden alterations of load which takes place in these machines when used for traction purposes. In working, these machines run without heating, and the current is maintained at constant value with great accuracy.

Sir Frederick Bramwell, in his report on the Northfleet Tramways, states of this firm's constant-current generator:

Fig. 1.

dynamo (Fig. 1) as supplied for driving tramways in the Via Flaminia, at Rome. This machine is fitted with Statter and Brunton's patent automatic regulator, and maintains a constant current of 60 amperes with a maximum pressure of 750 volts at 750 revolutions. It will be seen from Fig. 1 that the machine has double-circuit field-

"The dynamo is self-adjusting in its maintenance of a constant current. It is extremely interesting to watch the sensitiveness of this apparatus, and the manner in which it even forestalls the action of the engine governor (a sensitive high-speed governor). There are also two self-regulating series motors. These are of the same type as the

Fig. 3.

generator shown in Fig. 1, and these are provided with patent regulators wherein the movement of the brushes is controlled by the action of a sensitive centrifugal governor. It is in this manner that great sensitiveness is obtained. The Statter-Brunton self-regulating gear has been described in these columns before, but it has been perfected in

FIG. 3.

constructional details and made more compact. It can now be adjusted in a few moments for a machine running in either direction. All working parts have been made amply

In all generators and motors made on this system the mechanism for regulating the current is enclosed in a small cast-iron oil bath attached to the commutator end-bearings,

FIG. 4.

and neither the solenoid in the case of the generator, nor the centrifugal governor in the case of the motor, are required to exert any sensible amount of force. They merely determine the engagement of one or other of the driving pawls. strong, and as they work in oil there is practically no wear and tear at all.

The corporation make these generators in nine standard sizes, ranging from five kilowatts up to 80 kilowatts, and a

corresponding series of constant-current motors, ranging from $4\frac{1}{2}$ h.p. up to 110 h.p.

The constant-current generator is also employed for driving arc lights in series, and for this purpose standard sizes are made capable of maintaining from six arc lamps in the smallest size up to 120 in the largest, of 2,000 c.p.

This corporation show their constant-current motors applied to a hoist. The adaptability of their constant system is well illustrated by this application. The hoist shown is capable of lifting one ton at a speed of 100ft. per minute. The regulation of the motor is by hand, and the motion of starting, stopping, and reversing is performed by the movement of a single lever and is effected with great ease; the current is never switched off the machine during working, but after the hoist is done with the brushes are placed at right angles to the neutral point, the motor then comes to rest and absorbs only the volts due to its resistance; it is then switched out of the circuit. Heavy sparking at the switches—inherent to all parallel systems of power distribution—is entirely avoided, and is one of the many advantages of the system. The hoist is wound for a constant current of 50 amperes, and about 200 volts when fully loaded.

made by the corporation; the cylinder diameter is 3in. and the stroke 4in.; the whole set goes in a small space.

Fig. 4 shows the standard type of dynamo manufactured by the corporation for all sizes beyond four kilowatts, and Fig. 5 shows the type for all sizes up to four kilowatts.

The dynamo of the larger type exhibited at the corporation's stand has an output of 240 amperes at 120 volts; the field-magnets are made entirely of soft wrought iron, well annealed, and the armature of the softest Swedish charcoal iron. The corporation make these machines for voltages up to 250 in three standard sizes, ranging from six kilowatts up to 77 kilowatts, and they are described in their catalogue as type B dynamos. The smaller machines made to the design shown in Fig. 5 are in three standard sizes, and are described as type A dynamos. The armature of the B machines are of the drum type, and of the A machines cylinder type.

Fig. 6 shows a geared motor, supplied by the corporation, and has a self-contained countershaft; the power may be taken off it by means of belt, ropes, or pitch chain, at a low speed.

TESLA'S NEW ALTERNATING MOTORS.

ne time past Mr. Nikola Tesla, whose previous lternating-current motors is well known, has been upon the study of these machines in order to decient methods for operating them on two wires f three, and still without the use of a commutator. neral principle upon which these machines are debased on the well-known fact that if a magnetic

Fig. 5.

Fig. 6.

The exhibit also includes a high-speed engine with automatic expansion governor (Turner-Hartnell's patent). The governor is keyed directly on to the crankshaft, and is shown in Fig. 2. It acts directly in the cut-off of the valve, and while controlling the speed of the engine admirably gives excellent result in point of economy in steam consumption. The engine is simple, since the available boiler pressure at the exhibition is low. The corporation make tandem compound engines of similar design, with an improved piston valve, and would have preferred to exhibit one of these engines had the steam pressure supplied by the executive of the exhibition been higher. Both simple and compound engines are made in eight standard sizes.

A 2 h.p. nominal Atkinson gas-engine, combined with a 40-light compound-wound dynamo, is also shown, and used to drive some Statter arc lamps in parallel; the set forms a very compact plant for lighting private houses, and will be specially useful where space is limited.

This exhibit also includes a 20in. projector made in accordance with the Admiralty specification. It is beautifully finished in every detail, and furnished with signalling gear and with Statter and Brunton's patent diverging [illegible]

From their office at the exhibition the corporation have carried out the lighting of the yacht "Katoomba," belonging to Kenneth M. Clark, Esq. Fig. 3 shows the set supplied for generating the current; the dynamo is compound wound, and gives 60 volts and 18 amperes at 1,400 revolutions; the engine of the smallest of the standard sizes

core, even if laminated, be wound with a coil and a current be sent through, the magnetisation of the entire core does not immediately ensue, the magnetising effect not being exhibited in all parts simultaneously. This Mr. Tesla attributes to the fact that the action of the current is to energise first those laminæ or parts of the core nearest the surface and adjacent to the exciting coil, and from thence the action progresses towards the interior. A certain interval of time, therefore, elapses between the manifestation of magnetism in the external and the internal sections or layers of the core.

If the core be thin or of small mass this effect may be inappreciable, but in the case of a thick core, or even of a comparatively thin one, if the number of alternation be very great, the time interval occurring between the manifestations of magnetism in the interior of the core and in those parts adjacent to the coil is more marked, and in the construction of such apparatus as motors which are designed to be run by alternating currents, Mr. Tesla has found it desirable, and even necessary, to give due consideration to this phenomenon and to make special provisions in order to obviate its consequences.

On the other hand, by taking advantage of this very action or effect, and by rendering it more pronounced, Mr. Tesla utilises it in the operation of motors in general. This he effects by constructing a field in which the parts of the core that exhibit at different intervals of time the magnetic effect imparted to them by alternating currents in an energising coil are so placed with relation to a rotating

armature as to exert thereon their attractive effect successively in the order of their magnetisation. By this means there is secured a result similar to that which Mr. Tesla has heretofore attained in the previous types of his motor, in which by means of one or more alternating currents he produces a rotation or progression of the magnetic poles or points of maximum attraction of the field of force.

The general principle involved in the action above mentioned is illustrated in the simple motor shown in Fig. 1. Here X represents a large iron core composed of a number of sheets or laminæ of soft iron or steel. Surrounding this core is a coil, Y, which is connected with a source, E, of rapidly varying currents.

Let us consider now the magnetic conditions existing in this core at any point, as *b*, at or near the centre, and any other point, as *a*, nearer the surface. According to Mr. Tesla, when a current impulse is started in the magnetising coil, Y, the section at *a*, being close to the coil, is immediately energised, while the section at *b*, which, to use a convenient expression, is "protected" by the

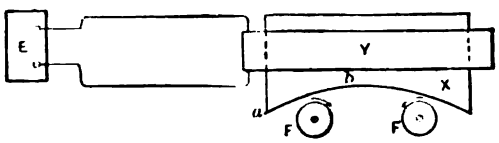

Fig. 1.

intervening sections or layers between *a* and *b*, does not at once exhibit its magnetism. However, as the magnetisation of *a* increases *b* becomes also affected, reaching finally its maximum strength some time later than *a*. Upon the weakening of the current the magnetisation of *a* first diminishes, while *b* still exhibits its maximum strength, but the continued weakening of *a* is attended by a subsequent weakening of *b*. Assuming the current to be an alternating one, *a* will now be reversed, while *b* still continues of the polarity first imparted. This action continues, the magnetic condition of *b* following that of *a* in the manner above described.

If an armature, for instance, a simple disc mounted to rotate freely on an axis, be brought into proximity to the core, a movement of rotation will be imparted to the disc, the direction depending upon its position relatively to the core, the tendency being to turn the position of the disc nearest to the core from *a* to *b*, as indicated in Fig 1.

This action or principle of operation has been embodied in a practical form of motor, which is illustrated in Fig. 2.

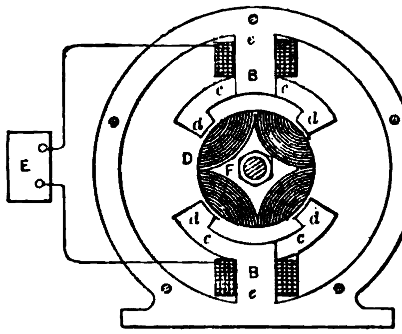

Fig. 2.

Here A represents a circular frame of iron, from diametrically opposite points of the interior of which the cores project.

Each core is composed of three main parts, B B and C, and they are similarly made with a straight portion, *e*, around which the energising coil is wound, a curved arm or extension, *c*, and an inwardly projecting pole, *d*.

Each core is made of two parts, B B, with their polar extensions reaching in one direction and a part, C, between the other two and with its polar extension reaching in the opposite direction. These cores are wound with coils, D, which are connected in the same circuit either in parallel or series and supplied with an alternating current by a generator, E, represented diagrammatically. Between the cores or their polar extensions is mounted an armature, F wound with magnetising coils, G, that are closed upon them selves, similar to those in the older types of Mr. Tesla's motors.

The operation of the motor is as follows: When a current impulse or alternation is sent through the coils, D, the sections, B B, of the cores being on the surface, and in close proximity to the coils, are immediately energised. The sections C, on the other hand, are protected from the magnetising influence of the coil by the interposed layers of iron, B B. As the magnetism of B B increases, however, the sections C are also energised, but they do not attain their maximum strength until a certain time subsequent to the exhibition by the sections B B of their maximum. Upon the weakening of the current the magnetic strength of B B

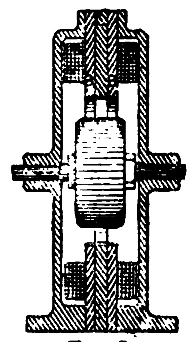

Fig 3.

first diminishes while the sections C have still their maximum strength; but as B B continue to weaken, the interior sections are similarly weakened. B B may then begin to exhibit an opposite polarity, which is followed later by a similar change on C, and this action continues. B B and C may, therefore, be considered as separate field-magnets, being extended so as to act on the armature in the most efficient positions, and the effect is similar to that in Mr. Tesla's other forms of motor—viz., a rotation or progression of the maximum points of the field of force. Any armature, such, for instance, as a disc mounted in this field, would rotate from the pole first, to exhibit its magnetism to that which exhibits it later. In follow

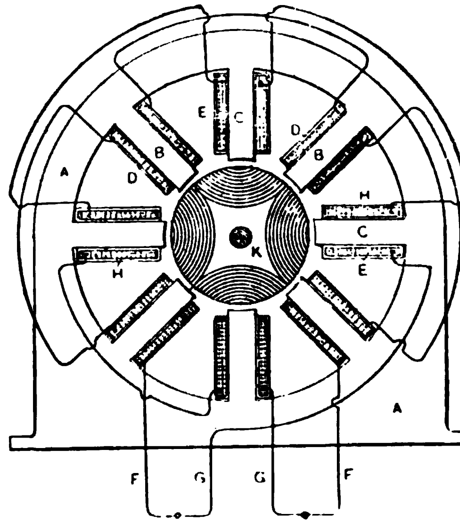

Fig. 4.

ing out the ideas stated above, Mr. Tesla has applied them to a class of motors in which two or more sets of energising magnets are employed and in which by artificial means a certain interval of time is made to elapse between the respective maximum or minimum periods of their magnetic attraction or effect. This has already been applied to the operation of Mr. Tesla's three-wire motors. In the present instance Mr. Tesla employs a motor with two sets of energising or field-magnets, each wound with coils connected with a source of alternating currents, but forming two separate paths or circuits. The magnets of one set are protected to a certain extent from the energising action of the current by means of a magnetic shield or screen of laminated iron interposed between the magnet and its energising coil.

The shield is properly ada ted to the conditions of par

ticular cases so as to shield or protect the main core from magnetisation until it has become itself saturated, and no longer capable of containing all the lines of force produced by the current. By this means it will be seen that the energising action begins in the protected set of magnets, a certain arbitrarily-determined period of time later than in the other, and that by this means a practically economical difference of magnetic phase may readily be secured.

The nature and operation of this motor will be readily understood by reference to the accompanying illustration. The engraving, Fig. 4, shows the simplest form of this type of machine. The cores B form one set of magnets, and are energised by coils D, while the cores C, forming the other set, are energised by coils E, and the coils are connected in series with one another, in two derived or branched circuits, F G, respectively. Each coil E, it will be noted, is surrounded by a magnetic shield, H, which is composed of an annealed insulated or oxidised iron wire wound on the coils in the manner indicated, so as to form a closed magnetic circuit around the coils, and between the same and the magnetic cores C. Between the pole-pieces or cores, B C, is mounted the armature of the closed circuit coil type.

The operation resulting from this arrangement is as follows: If a current impulse be directed through the two circuits of the motor, it will quickly energise the cores B, but not so the cores C, for the reason that in passing through the coils E there is encountered the influence of the closed magnetic circuits formed by the shields, H. The

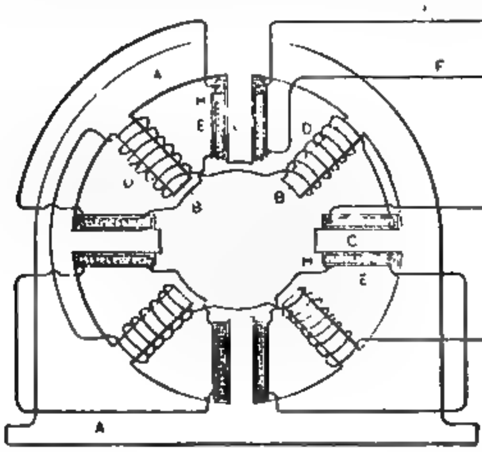

FIG. 5.

first effect is to effectively retard the current impulse in circuit G, while at the same time the proportion of current which does pass does not magnetise the cores C, which are shielded or screened by the shields, H.

As the increasing E.M.F. then urges more current through the coils E, the iron wire, H, becomes magnetically saturated and incapable of carrying all the lines of force, and hence ceases to protect the cores C, which become magnetised, developing their maximum effect after an interval of time subsequent to the similar manifestation of strength in the other set of magnets, the extent of which may be arbitrarily determined by the thickness of the shield, H, and other well-known conditions.

From the above it will be seen that the apparatus or device acts in two ways. First, by retarding the current, and second by retarding the magnetisation of one set of cores, from which its effectiveness will readily be seen.

Many modifications of the principle here embodied have been made by Mr. Tesla, one only more of which we may notice here. This is illustrated in Fig. 5, and is similar in all respects to that above described, except that the iron wire, H, which is wrapped around the coils E is in this case connected in series with the coils D. The iron wire coils are connected and wound so as to have little or no self-induction, and being added to the resistance of the circuit F, the action of the current in that circuit will be accelerated, while in the other circuit, G, it will be retarded.

Still another type of motor, constructed by Mr. Tesla is one with a field-magnet having two sets of poles or inwardly projecting cores, and placed side by side so as practically to form two fields of force, and alternately arranged—that is to say, with the poles of one set or field opposite the spaces between the other. The free ends of one set of poles are then connected by means of laminated iron bands or bridge-pieces of considerably smaller cross-section than the cores themselves, so that the cores all form parts of complete magnetic circuits.

When the coils on each set of magnets are connected in multiple circuits from an alternating machine E.M.F.'s are set up in each circuit simultaneously, but the coils on the magnetically bridged or shunted cores will have, by reason of the closed magnetic circuits, a high self-induction which retards the current, permitting at the beginning of each impulse but little current to pass. On the other hand, no such opposition being encountered in the other set of coils, the current passes freely through them, magnetising the poles on which they are wound.

As soon, however, as the laminated bridges become saturated and incapable of carrying all the lines of force which the rising E.M.F., and consequently increased current, produce, free poles are developed at the ends of the cores, which, acting in conjunction with the others, produce rotation of the armature. The construction by which this is accomplished is shown in the accompanying engravings, Figs. 6 and 7.

The frame of the motor, A, is built up of sheets of iron punched out to the desired shape and bolted together with insulation between the sheets. When complete the frame makes a field magnet with inwardly projecting pole-pieces, B and C. To adapt them to the requirements of this particular case, these pole-pieces are out of line with one another, those marked B surrounding one end of the armature, and the others, C, the opposite end, and they are arranged alternately—that is to say, the pole-pieces of one are set in line with the spaces between those of the other sets. The pole-pieces, C, are connected or shunted by

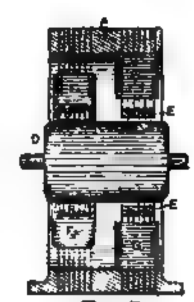

FIG. 6. FIG. 7.

bridge-pieces, E. The coils, F and G, are connected in series, respectively, in two circuits which are branches of a circuit from an alternating machine, and they are so wound that the circuit of coils G will have a higher self-induction than the other circuit or branch.

The function of the shunts or bridges, E, is that they shall form with the cores, C, a closed magnetic circuit for a current up to a predetermined strength, so that when saturated by such current and unable to carry more lines of force than such a current produces, they will, to no further appreciable extent, interfere with the development by a stronger current of free magnetic poles at the ends of the cores, C.

In such a motor the current is so retarded in the coils G, and the manifestation of the free magnetism in the poles C, is delayed beyond the periods of maximum magnetic effect in poles B. The result is that a strong torque is produced and the motor operates with approximately the power developed in a motor of this kind energised by independently generated currents differing by a full quarter phase. *Electrical Engineer* (New York).

Electric Deposition of Dust.—Prof. Förster says that the electric deposition of dust from smoke and other sources in practice presents very great difficulties, and is not successful unless the air to be cleared is at rest, and the walls to which the dust is to adhere is sticky. The dust whirls away after lighting on the surface and is carried off even by a very gentle stream of air. The professor's experiments were made at the German Imperial Sanitary Department.

HOW TO ESTABLISH A CENTRAL ELECTRIC LIGHTING STATION.

BY SYDNEY F. WALKER.

(Continued from page 144.)

It is an open question, where continuous-current dynamos are used, whether the night work can be dealt with most advantageously by means of accumulators, or by having a few small engines and dynamos as already explained. The latter has the advantage that it keeps battery work, chemicals, etc., out of the central station entirely, so that men who have only a knowledge of the mechanics of electricity may be employed. Going into secondary batteries is going into another science, learning something entirely new. Dealing with dynamos is not so much so, nearly all the attention required to them being such as any intelligent mechanic easily acquires. Further, it must not be forgotten that there is considerable loss attending the use of accumulators. There is the 25 per cent. or so residual charge which must not be taken out, and there is the double loss of conversion, which means additional coal, water, etc., for the same work. In addition to this, the first cost of secondary batteries is high compared to that of engines and dynamos. On the other hand, the use of secondary batteries enables a smaller plant to do the work, as, in place of using the whole power of the engines and dynamos only for the one or two hours when all the lights are required, they might all be working all day charging accumulators, and the current required during the busy time could be taken from the dynamos and the accumulators together. In America this has been done with considerable success, but from the paper on the subject contributed by Mr. Geo. Prescott, jun., to the American Institute of Electrical Engineers, it would appear that somewhat complicated switching and adjusting arrangements have been found necessary. One great difficulty attending the use of accumulators with dynamos, taking the current for the lamps direct from the mains to which both dynamo and accumulator are connected, is the danger that the dynamo E.M.F. at the terminals of the accumulator may fall below that of the accumulator itself at the same point, in which case the dynamo wires become a path for the discharge of the accumulator current, just as in the case of dynamos connected in parallel. In the writer's opinion, however, this difficulty can also be overcome by the method of subdivision of the mains already recommended. Let the dynamos be set to charge accumulators during the day, but each dynamo charging its own battery, not all the dynamos connected in parallel to all the accumulators. Then, before the busy time comes on, let all the accumulators be disconnected from their respective dynamos, and let each set be treated as advised for the dynamos, ready to be switched on to any circuit as required. After the busy time is over let the dynamos be stopped one after the other, and the work left to the accumulators. Where a day supply is required, as in dark city offices and similar situations, or in case of fog, one or more dynamos and engines must be kept free for this purpose, and a dynamo or two can be kept running during the night if any of the accumulators should be run down below the safe limit. If would not be safe to leave accumulators to themselves at a central station any more than it would be to leave engines and boilers, though there ought to be scarcely anything for the man in charge to do, and it might be necessary to devise an elaborate record of tests to be entered, so that he might have something to keep him awake. But this is no more than is now frequently the case with large engines which are continuously running, such as the fan engine at a colliery. The engine man has very little to do, but he must be there in case of accident. So the man in charge of accumulators would have to be ready to add cells and to take off bad ones, in case of a sudden collapse of one or two; and he ought even to have the fires of one boiler banked, so that he could run an engine in case of necessity. The question, therefore, whether accumulators shall be used or not, becomes, except in special cases, purely one of first cost and maintenance cost.

In the one case, a certain engine and boiler power is laid down, and steam is kept up, say, from 3 p.m. to 8 a.m. next morning, or if there is a day service as well, the whole day and night; only the full power of the engines being used for about two hours in winter and not at all in summer. In the other case, a much smaller engine plant is fixed, and steam is only maintained for 10 to 12 hours; but to the cost of the engine and dynamo plant must be added the cost of accumulators to take part of the work at the busy time and the night work; and to the cost of firing for 12 hours must be added the cost of attendance on the accumulators while charging and discharging, and the cost of their renewals.

Next, as to what engines should be employed. The opinion has already been expressed that these should be divided up as much as possible. The writer would also recommend their being of as simple construction as possible, and all having two cylinders. The double-cylinder engine runs more steadily than the single-cylinder; it is necessarily smaller for the same power, and can be arranged to run faster on whatever principle it may be constructed,and is therefore more easily set to drive the dynamo without the intervention of countershafts. The latter should be avoided where possible; they add considerably to the expense, absorb power, and take up room. For belting, almost any form of well-made belting is suitable. The plan which has come into fashion within the past few years, also, of driving by ropes over grooved pulleys has many advantages. One point against it is that if the rope breaks, whether it be one rope passing several times round the same pulleys (or several ropes, each running in its own groove) the whole of the rope is almost certain to be destroyed. The question of what kind of dynamo should be used need hardly be discussed further here, but the writer would reiterate the warning he has so often given. Let them be as simple as possible. Do not barter simplicity for 5 per cent. or even 10 per cent. efficiency. It is a bad bargain, and will almost inevitably cost you more than you gain. If your station is successful, you may have a difficulty in manning it with really skilled men; then is the time when you will feel the pinch of your so-called high-efficiency dynamos. Something may happen to them which only the maker can put right, because it is a part of the special arrangement by which he gets his extra efficiency, and the cost to you makes a considerable addition to your expenses for the year; whereas, with simple machines, your own men, if well trained, will deal with everything that turns up, the only assistance you require from the maker being the supply of the wearing parts.

Before passing on to the commercial side of the matter, it may be as well to consider a point that is often taken as conclusively established—namely, the use of feeder mains in connection with central station work. The idea of keeping different parts of the district in touch, so to speak, with the centre is a remarkably good one, as are most of the ideas emanating from Mr. Edison; but it is doubtful, in the writer's opinion, if the idea is of great commercial value as applied to feeder mains. The object to be attained is the reinforcement of the E.M.F. at practical centres of distribution by mains direct from the source of supply, the E.M.F. in which has not been exposed to a charge for the passage of the current supplying lamps between it and the source, and the ultimate gain is a saving of copper. But this saving is effected at the cost of additional wires underground, and the saving is partly counterbalanced by the cost of the insulation of the feeders, the expense of joints, etc. The writer is aware that the same objection may be raised, in part, at least, to the system of division he recommends. But he thinks the two cases are hardly alike. The object to be attained by allotting to each dynamo its own work, irrespective of what the others may be doing, is simplicity in detail, and reduced cost of maintenance, owing to the greater safety in running. The object to be attained by feeder mains is a small saving in copper, at a very possible increased cost of maintenance. Further than that, except under the special conditions of supply to be mentioned below, while meters are making their name, the division would be by districts; the latter being only divided where the supply was large, and in that case there would be far less complication and less chance of wrong connections being made where two or more positive mains were laid together for a certain distance, and two or more

negatives for the same, than where a number of mains emanated from the same source but terminated at different places. It will be when cables become faulty that this will be felt; the difficulty of finding the particular cable at each box, unless very carefully marked and the marks carefully preserved, will be added to the trouble of locating the fault itself.

It appears to be assumed that feeders may be laid down as the supply of current increases, but it will be most unwise to reckon on this. Tearing up the streets will have to be resorted to as seldom as possible, not only on account of the nuisance to traffic, but on account of the expense. It will in the majority of cases be easier and cheaper to lay down mains in the first instance for the whole of the supply that there is any reasonable probability of securing, and later—much later—if the town itself has grown, or if from other causes the demand has outgrown the cables, lay down for a further substantial supply, than to be adding driblets from time to time, in the shape of additional feeder mains. Prepare your estimate, as suggested in the beginning of the paper, for all the supply you can possibly get—all you ought to get if the supply is good—and work to that as the portion of capital account due to cables.

Next, having laid out your station and secured consumers, how will it be best to charge, and what sort of a supply will you give? Answering the latter question first, the writer's view is that you should come to a consumer, and be ready to supply him with any kind of light from 8 c.p. up to the largest incandescent lamp that is made, and let him turn it on when he wants it just as he now does gas. You should also be prepared to give him an arc lamp if he fancies it; but there is the objection to an arc lamp that it is not under his own control unless he keeps a man to clean the lamp, change carbons, etc., besides which the large incandescent lamps are far superior for every kind of work, and cheaper to maintain. Before long, no doubt, an income will be earned from the use of the current for power, and possibly for heating; but at present it would be wiser to reckon only upon its use for lighting.

(To be concluded.)

TESLA'S TRANSFORMER FOR MOTOR WORK AND FOR CONSTANT CURRENT.

In the early forms of alternating motor brought out by Mr. Tesla the construction embodied a series of coils traversed by currents differing a quarter phase from one another. This has in some forms required three wires from the generator to the motor, but in order to avoid this Mr. Tesla has recently constructed a converter specially designed to be used in connection with his motor, and in which the difference of phase required is spontaneously brought about. This converter also possesses the valuable property that it operates with a constant current for all loads imposed upon the secondary.

In transformers as at present constructed it is found that the E.M.F. of the secondary very nearly coincides with that of the primary, being, however, of opposite sign. At the same time the currents, both primary and secondary, lag behind their respective E.M.F.'s, but as this lag is practically the same in the case of each, it follows that the maximum and minimum of the primary and secondary currents will nearly coincide, but differ in sign or direction, provided the secondary be not loaded, or if it contain devices having the property of self-induction.

On the other hand, the lag of the primary behind the impressed E.M.F. may be diminished by loading the secondary with a non-inductive or dead resistance—such as incandescent lamps—whereby the time interval between the maximum or the minimum periods of the primary and secondary currents is increased. This time interval, however, is limited, and the results obtained by phase difference in the operation of such devices as Mr. Tesla's alternating-current motors can only be approximately realised by such means of producing or securing this difference, as above indicated. For it is desirable in such cases that there should exist between the primary and secondary currents a difference of phase of 90deg., or, in other words, the current in one circuit should be maximum when that in the other circuit is minimum.

To more nearly and perfectly attain to this condition Mr. Tesla secures an increased retardation of the secondary current in the following manner: Instead of bringing the primary and secondary coils or circuits of a transformer into the closest possible relations, as has hitherto been done, he protects in a measure the secondary from the inductive effect of the primary by surrounding either the primary or the secondary with a comparatively thin magnetic shield or screen.

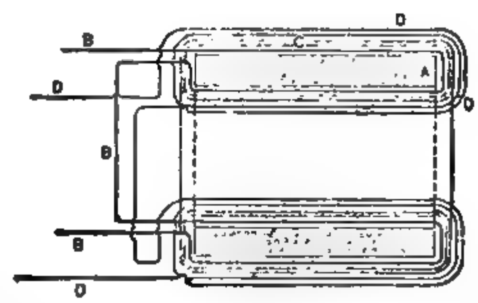

Fig. 1.

Under these conditions, as long as the primary current has a small value the shield protects the secondary, but as soon as the primary current has reached a certain strength, which is arbitrarily determined, the protecting magnetic shield becomes saturated and the inductive action upon the secondary begins. It results, therefore, that the secondary current begins to flow at a certain fraction of a period later than it would without the interposed shield, and since this retardation may be obtained without necessarily retarding the primary current also, an additional lag is secured, and the time interval between the maximum or minimum periods of the primary and secondary currents is increased.

Mr. Tesla has also discovered that such a transformer may by properly proportioning its elements be made to yield a constant current at all loads.

In the accompanying illustrations Fig. 1 is a cross-section of a transformer embodying the above idea. A A is the main core of the transformer composed of a ring of annealed iron wire. Upon this core is wound the secondary circuit, B B. This latter is then covered with a layer of annealed iron wires, C C, wound in a direction at right angles to the secondary coil. Over the whole is then wound the primary coil, D D.

Generator.

Fig. 2.

From the nature of this construction it will be obvious that as long as the shield formed by the wires, C, is below magnetic saturation, the secondary coil or circuit is effectually protected or shielded from the inductive influence of the primary.

When the strength of the primary reaches a certain value, the shield, C, becoming saturated, ceases to protect the secondary from inductive action, and current is in consequence developed therein. For similar reasons, when the primary current weakens, the weakening of the secondary is retarded to the same extent.

In the engraving, Fig. 2, the core, A, is built up of insulated iron plates or discs. The primary circuit, D, is wound next to core, A. Over this is applied the shield, C, which in this case is made up of thin plates of iron properly insulated and surrounding the primary, forming a closed

magnetic circuit. The secondary, B, is wound over the shield, C.

In Fig. 2 the primary of the transformer is connected with the circuit of the generator. F is a two-circuit alternating-current motor, one of the circuits being connected with the main circuit from the source, E, the other being supplied with currents from the secondary of the transformer.—*Electrical Engineer* (New York).

THE LANE FOX CLAIMS.

We are asked to give publicity to the following circular letter, etc., which is interesting and important at this juncture of affairs:

"Sir,—Your attention has perhaps been called to certain claims which have recently been put forward by the Lane Fox Electrical Company, Limited, with regard to the system of distribution by means of secondary batteries in conjunction with dynamos. The Lane Fox Company claim the exclusive use of this system by virtue of the patents granted to Mr. Lane Fox in 1878, and they are demanding royalties accordingly.

"Amongst others against whom the claim has been made is my company, and my directors have therefore caused the matter to be investigated, and have obtained an opinion from their technical and legal advisers as to the validity of the claim. The result has been to satisfy them that the claim cannot be sustained, and they therefore propose to resist it.

"The case, however, is obviously one in which successful resistance on the part of any one defendant will enure for the benefit of all who are making use of the system, and it appears to my directors that it would only be prudent and expedient that all concerned should co-operate in the defence. They have, therefore, instructed me to communicate with you, and with others whom they believe to be interested, with a view of forming an association for the purpose of offering combined opposition to the claims of the Lane Fox Company.

"It is not yet known against whom that company will direct its first attack, but it is obviously desirable that whoever may be thus selected should contest the case thoroughly, so as to secure a decision which will protect all other users. The question interests alike the supplying companies, the contractors who do electrical work, and the private individuals who use the system in their private installations, and it appears to my directors that an opportunity of co-operation should be given to all concerned.

"My directors have already opened communication with several of the other companies interested, and two or three of them, including amongst others the Westminster Electric Supply Corporation, Limited, and Messrs. Crompton and Co., Limited, have promised to co-operate. Further, the opinions of Sir Frederick Bramwell, Mr. Swinburne, and Mr. Kapp have been obtained, all of whom agree in advising that the claims of the Lane Fox Company cannot be sustained. These opinions have been submitted to counsel on behalf of my company, and counsel's opinion is to the like effect. My directors, therefore, feel justified in believing that the claims could be resisted successfully, and they think this could best be done by the formation of an association upon some such basis as is indicated in the terms set out on the enclosed paper.

"I am now instructed to ask whether you will be prepared to join such an association. You will observe that it would not commit you to a larger expense than £ unless after consideration of the matter in general meeting you should be willing to carry your liability further.

"Probably it will be found convenient, if a satisfactory number of adhesions should be received, to form a small committee to represent the association and direct any proceedings which may be taken for the common benefit, it being always understood that neither the committee nor the association itself should have the power to compel the continuance in the association of any member who desired to withdraw or to impose upon any such member any pecuniary responsibility beyond that which the member might actually have agreed to undertake.

"My directors would be willing to give the association the use of this company's office for the purpose of carrying on the work, so that no expense need be incurred except such as may be incidental to the employment of technical and legal advisers, and such printing and stationery as may be necessary.

"It would be well to get the association formed without delay, and if possible before the commencement of proceedings by the Lane Fox Electrical Company, Limited. I shall therefore be glad to be favoured with your views on the subject at your earliest convenience.—Yours faithfully,

"R. S. ERSKINE, secretary,
"The Kensington and Knightsbridge Electric
"Lighting Company, Limited.

"PROPOSED BASIS FOR THE FORMATION OF A DEFENCE ASSOCIATION.

"An association of companies, firms, and persons using secondary batteries as accumulators of electrical energy in connection with the supply of current from dynamos, for the following objects:

"1. To defend any action that may be brought against any of them by the Lane Fox Electrical Company, who are threatening to commence actions in respect of the letters patent owned by them, and alleged to cover the system of supply above mentioned.

"2. To take such advice and collect such information as may be necessary for the protection of the rights of the several members of the association to use the system of supply above mentioned.

"3. Supply companies to subscribe a minimum of £50, contractors £25, and owners of private installations £10, to be called up as required; this would entitle members thus constituted to claim that the association should defend any action to the extent of the funds subscribed, and any additional amount which may from time to time be voted in general meeting which might be brought against them by the Lane Fox Electrical Company in connection with the above-named claims.

"4. Should further funds be required the members are to be called upon to subscribe in the ratio of the sums above mentioned, according to their respective denominations.

"5. Any member of the association may retire at any time, in which event this association shall no longer be under any liability to defend any action which may have been brought, or may be brought, against the member in question."

THE THOMSON-HOUSTON SYSTEM OF ELECTRIC TRACTION IN BREMEN.*

The Germans are the first to introduce the Thomson-Houston system of electric traction into Europe, a line on that system having been opened in Bremen on June 22 last. The tramway commences in the centre of the town, near the town hall, passes by the new railway station, and finishes at Ausstellungs-platz, inside the entrance to the Bürger Park. The generating station is about 220 yards distant from this entrance. It contains a boiler constructed by the firm of Pétry-Déreux, a steam-engine of 150 i.h.p., made by Küchen, of Düsseldorf, and a dynamo of 84 e.h.p., having a terminal pressure of 500 volts. The latter is driven by belting from the engine. In addition to these, there is installed an Armington-Sims high-speed engine of 70 h.p., which actuates on an arc light dynamo used for lighting purposes only. Another dynamo of the same capacity as the first will shortly be laid down. This installation supplies current for—(1) the working of the electric tramway; (2) for the operation of a 15 h.p. motor placed in the Vienna Bakery in Ausstellungs-platz, where the motor drives some kneading machines and an arc light dynamo for illuminating the buildings; (3) for the lighting of arc lamps and glow lamps arranged in series and installed on the Freien-platz; (4) for the illumination by means of glow lamps of that portion of the line from the railway viaduct to the park, and of several groups of glow lamps installed in two streets.

The conductors are carried on insulators attached to the lower ends of short pieces of steel cable, the upper ends being fixed to steel and cast-iron standards. The conductors consist of copper wires 8·25 mm. thick. Under the railway viaduct they are carried only on insulators fixed to the arch or the viaduct,

* Abstracted from the *Elektrotechnische Zeitschrift.*

and in one narrow street they are installed transversely from house to house. In ordinary service there are five to six cars, which run at intervals of from four to five minutes. If it is desired, an extra car can be coupled to each of the electric cars. Fixed on the roof of each car is a supporting arm placed at an angle of 40deg. This support, which lies horizontally when the car passes under the before-mentioned viaduct, carries a contact roller having a deep groove, and pressing against the underside of the overhead conductor. A short piece of insulated conductor is attached to the contact roller and leads down to the motors. There are plenty of curves, but they are of short radius, and suitable leading pieces are provided at the curves so that the contact roller may maintain its proper position. There are two motors slung on a special framework under each car, each motor actuating a separate axle. The current from the generating dynamo leaves the positive brush and passes along the overhead main, which is placed about 20ft. above the middle of the track. It is then collected by the contact rollers, passes through the motors to the car-wheels, and thence back to the negative brush by the rails. The rails are connected by copper wires, which are riveted to them. The cars are fitted with brakes, brushes for clearing obstacles off the track rails, safety appliances, etc. At the depot pits have been made so as to facilitate access to the motors, etc. The tramway, which is about one mile long, and nearly double throughout, is being well patronised, one point in its favour being the holding of an industrial exhibition in the Bürger Park.

COMPANIES' MEETINGS.

GENERAL ELECTRIC.

The statutory general meeting of the shareholders of the General Electric Company, Limited, took place on Tuesday at the offices, 71, Queen Victoria-street.

Mr. Gustav Binswanger (the chairman of the Company), who presided, stated that the business of the Company was divided into three departments—electric lighting, electric bells, and the works at Manchester. The result of the trading was that they were able to recommend a dividend of 15 per cent. on the preference shares, and of 7½ per cent. on the ordinary shares, carrying, at the same time, a sum of £637 to reserve. This result must be considered extremely satisfactory, inasmuch as the earning power of the Company upon the actual capital invested was more than 25 per cent. per annum. The business was continuing to show a very substantial increase, and as the winter was the best time for a business of this description, they had every prospect of being able to double the returns. The Chairman concluded by moving the adoption of the report and accounts.

Mr. Myerstein seconded the resolution, which was unanimously agreed to, and the dividends as recommended were also declared.

Mr. T. J. Seel was re-elected auditor of the Company.

Mr. Hess proposed, and **Mr. Goldschmidt** seconded, a vote of thanks to the Chairman and Directors, and the meeting separated.

NEW COMPANIES REGISTERED.

Gordon Electric Traction Syndicate, Limited.—Registered by Gilbert Robins, 11, Pancras-lane, E.C., with a capital of £2,400 in £10 shares. Object: to acquire the invention of John Gordon of a system of electric street car traction and the provisional protection for the same, dated May 5, 1890. Most of the regulations of Table A apply.

Nonpareil Electric Syndicate, Limited.—Registered by A. H. Fowler, 2, Victoria-mansions, S.W., with a capital of £6,000 in £100 shares. Object: to acquire letters patent, granted October 11, 1889, to Joseph Mason for a new or improved automatic, coin-freed machine for giving electric shocks. Registered without articles of association.

PROVISIONAL PATENTS, 1890.

AUGUST 11.

12532. **Improvements in electric lighting.** Sydney Pitt, 24, Southampton-buildings, London. (Sautter Harlé and Co., France.) (Complete specification.)

12562. **New or improved means or apparatus for generating electricity.** William Oswald Stanley, 17, Southampton-buildings, London.

12566. **Improvements in electric arc lamps.** Edwin Charles Russell, 45, Southampton-buildings, London.

AUGUST 12.

12628. **Improvements relating to the welding of metals by electricity.** Herbert Ellsworth Fowler, 45, Southampton-buildings, London. (Complete specification.)

12634. **Improvements in dynamo-electric machines or electric motors.** Theodore Marshall Foote, 45, Southampton-buildings, London. (Complete specification.)

AUGUST 13.

12713. **Improvements in electric mains, and in apparatus used in their manufacture.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London.

AUGUST 14.

12737. **Improvements in appliances for conducting electric currents.** John Mackintosh Mackay Munro, 154, St. Vincent-street, Glasgow.

12763. **Improvements in or relating to electrical batteries.** Eugene Buffet, 323, High Holborn, London.

12777. **Improved safety connections or couplings for electric conductors.** Robert Howe Gould and Theodor Gottschalk, 55, Chancery-lane, London. Complete specification.)

12784. **Improvements in underground conduits and conductors for electrical transmission.** Reginald William James, 1, Queen Victoria-street, London. (William John Brewer, United States.)

AUGUST 15.

12819. **Improvements in column type printing instruments operated electrically, for telegraphic and other purposes, and in conductors therefor, which latter are also applicable for telephonic and electric transmission generally.** Samuel Dickinson Williams, Moorlinch House, Clytha Park, Newport.

12827. **Improvements in armatures for dynamo-electric machines.** Henry James Hilton, 37, Chancery-lane, London.

12830. **Improvements in secondary batteries and electrodes therefor.** Henry Harris Lake, 45, Southampton-buildings, London. (George Augustine Johnson and Sidney Latham Holdrege, United States.) (Complete specification.)

12832. **An electrical wattmeter, also applicable as an ammeter or voltmeter.** Ernest Wilson, 28, Southampton-buildings, London.

AUGUST 16.

12874. **Improved electric switch.** Christen Rees Bonne, 41, Eastcheap, London. (The Actien Gesellschaft Mix and Genest, Germany.

SPECIFICATIONS PUBLISHED.

1889.

7005. **Galvanic batteries.** Schanschieff. 6d.
10640. **Electric arc lamps.** Crampton and Essinger. 8d.
12185. **Distributing electricity.** Howard. 11d.
13553. **Electrical railway signalling apparatus.** Edwards (Perls). 8d.
14366. **Arc lamps.** Boult. 8d.
14464. **Electricity meters.** Batault. 8d.
14590. **Electric bells.** Groves and Stewart. 8d.
14871. **Baths for electro-plating, etc.** Hopkinson and Appleton. 6d.
16586. **Electric switches.** Marcher and Ernecke. 8d.
17060. **Electrical furnaces.** Parker. 8d.
18980. **Suspending electric lamps.** Bradner. 8d.

1890.

8241. **Electric lamp hangers.** Jeffers. 8d.
8796. **Electric circuit controlling apparatus.** Gill. 8d.
9857. **Welding, etc., metals by electricity.** Dewey. 8d.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the week ended August 15 amounted to £4,838.

West India and Panama Telegraph Company.—The estimated receipts for the half-month ended August 15 amounted to £2,530, as compared with £2,368.

Western and Brazilian Telegraph Company, Limited.—The receipts for the week ended August 15, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,718.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	1¾
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	8

NOTES.

Konigsberg.—The central station at Königsberg is announced to be opened on 7th October.

Essen.—An installation for the transmission of power for a large manufactory has been carried out at Essen in Germany.

Arc Lighting.—Boston (U.S.) has now 800 public arc lights running. The price is 40 cents (1s. 8d.) per lamp per night.

Colonial Tenders.—Messrs. Siemens and Halske and Messrs. Ganz and Co. are tendering for work in Bombay and Sydney.

Electric Railway in Carlsbad.—An electric railway is to be shortly established at the well-known watering place of Carlsbad.

Electric Tramway in Paris.—We are informed that an electric tramway is now being put on service between the Place Pigalle and the Trocadéro, Paris.

Electric Fans on Railways.—The Chicago and Alton Railway claims to be the first to introduce ventilating and cooling fans driven by electric motors in the parlour cars.

Storage Cars in Dresden.—Experiments are being made in Dresden with electric tramcars driven by accumulators. Herr J. L. Huber has carried out these experiments.

Milan Cathedral.—It is proposed to light up the exterior of Milan Cathedral at night by means of an immense projector electric lamp fitted on the summit of the principal tower.

Paper on Welding.—Prof. Elihu Thomson will read a paper before the New York meeting of the British Iron and Steel Institute in October on the "Thomson Electric Welding Process."

Berlin.—A new central station at Berlin, erected by the Kurfurstendamm Gesellschaft, will shortly be started in actual work. It has cost £30,000 and will supply the Grünewald quarter.

Electric Envelope Machine.—An envelope-making machine has been constructed by an American inventor, Mr. Ross, in which an electric automatic feed regulator is a prominent feature.

A Portable Theatrical Plant.—A dynamo and a complete electrical plant will be carried by "The Limited Mail" theatrical company, to produce the telegraph and other effects in that play.

Schefbauer Small Arc Lamp.—Mr. R. S[illegible]uer, of Paterson, New Jersey, makes an arc lamp of 80 to 200 c.p. extremely economical in operation, which is finding a very wide field in the States.

Bohemia.—At Teplitz, in Bohemia, the public contract with the gas company for lighting expires in 1891, and the town is in treaty with a Berlin firm for the establishment of a central electric light station.

Constantinople.—A combination of German, Swiss, and Belgium capitalists have recently organised a company under the title of the "Society for Lighting the Town of Constantinople," we suppose electrically.

Double-Carbon Lamps.—An injunction has been granted on final hearing against the Western Electric Co., in favour of the Brush Electric Co. of Cleveland, with reference to the use of double-carbon arc lamps.

Sims-Edison Torpedo.—Mr. Scott Sims, of the Sims-Edison torpedo firm, is building a torpedo boat to run at a speed of 18 miles an hour for the United States Government. The test of it is to take place in the fall.

Telephone in Kharkov.—On the 8th of July the telephone was inaugurated at Kharkov. There are several public call stations throughout the town by which, on payment of 25 copecks, five minutes' conversation can be obtained.

Telephony in Russia.—A French company, says the *Ingenieur Conseil*, has obtained the authority from the Russian Government for the establishment of long-distance telephone lines between St. Petersburg, Moscow, and Varsovie.

Edison-Lalande Battery.—This battery has scored quite a point in New York. At the Western Union building, just refitted, 350 of these cells have been put in use by the Edison Manufacturing Company, to replace a very much larger number of the cells in use before the recent fire.

Storage Battery Plant.—A lighting plant comprising storage batteries has been sold to the Grant's Pass Electric Light Company, Oregon, for a central station. It will be a 500-light plant, and is said to be the first central station storage battery plant on the Pacific Coast, outside of California.

Electric Lighting by Water Power.—A dam is to be built across the Des Chutes river, near Olympia, Washington, giving a 30ft. waterfall. It is estimated that this will give from 400 to 600 h.p. Six dynamos will be placed at the falls to generate current for electric light and power purposes.

Engine-Dynamo Efficiency.—Recent tests made by Mr. Gisbert Kapp, in the presence of Mr. W. H. Preece, of a Willans and Robinson engine and direct-coupled dynamo, for the new Birmingham post office, showed the total efficiency of indicated to electrical horse-power to be 87 per cent.

World's Fair.—Prof. Wm. A. Anthony, the president of the American Institute of Electrical Engineers, has been mentioned as a candidate for the position of electrical superintendent of the World's Fair in 1893. The name of Prof. Elisha Gray has also been prominently mentioned in connection with the same office.

Breslau.—A vote of a million marks has been made to provide a central station for Breslau of a capacity of 8,000 lamps, with extension to 30,000 lamps. The plans and tenders of Messrs. Siemens and Halske have been accepted. The system to be used will be continuous currents with accumulators charged during the day.

Electric Tramway in Sweden.—The first electric tramway in Sweden has been recently opened. It is intended for the transport of minerals to and from the metallurgical works at Boxholm. The motive force is furnished by a turbine of 50 h.p. driving two Wenstrom dynamos, and the current to the motors is carried by overhead conductors.

A New Alternating Motor.—Mr. Van Depoele, whose name is already well known in connection with electric traction work, has invented a new alternating-current motor. In this the alternating dynamo is not followed as a model, but the effect is utilised of an alternating field on the currents generated by it in a closed-circuit armature.

Thomson-Houston System in Italy.—The Italian electrical paper, *L'Elettricità*, came out last week with a supplement as large as itself entirely devoted to a description of the Thomson-Houston system, with a list of places in England, Scotland, Italy, France, Finland, Sweden, Belgium, Russia, and Spain at which the system is working.

An Electric Shock Accident.—In view of the universal interest aroused by the Kemmler execution, an accident which occurred on Saturday to an employé of an electric light company at Washington has evoked great attention. By an inadvertence the man received a shock of 2,000 volts; he became instantly insensible, but soon recovered, though the places where the current entered and left his body showed marks of burning, and were very painful.

Lightning in a Clock Factory.—A cyclone at Saint-Claude, in France, which occurred last week, amounts to a public disaster, houses having been demolished in all directions. At Saint-Claude the damages are said to be so great that 2,000,000f. would not cover them. Clear traces of lightning are visible on trees and house gutters, and the electricity was particularly destructive in a clock and watch factory, where the works of all sorts of clocks and watches were destroyed.

Personal.—Mr. James Dredge, editor of London *Engineering*, has been selected by the joint committee of the civil, mechanical, and mining engineering societies of the United States, says the *Electrical World*, to deliver the address at the unveiling of the memorial to be erected in honour of Alexander Lyman Holley in Washington-square, New York. The dedication is to take place early in October, during the New York meeting of the British Iron and Steel Institute.

Business Progress.—Messrs. Drake and Gorham record a steady increase in business, with several important installations in course of execution; amongst which may be mentioned the lighting of the new Metropolitan Police Buildings with 1,500 lights, the Western Branch of the Bank of England, and Alnwick Castle, for the Duke of Northumberland. The firm have been compelled to make extensive additions to their offices and stores to cope with the increase of work.

Concessions at Paris.—M. Cochin, according to a note in *Electricité*, has obtained from the Municipal Council of Paris the approval of two demands for concession of the electric lighting of the left bank of the Seine. M. Naze asks the concession extending from the Esplanade des Invalides to the Place Walhubert. The concession asked by M. Patin includes a part of the fifth arrondissement, and extends from the Boulevard Saint-Michel, to the fortifications by the Avenue d'Orléans and the quays.

Gas-Electrics in Carlsbad.—In Carlsbad, says the *Gas World*, the gas company holds the field till 1902. The town has built an electric station and leased it to the gas company until 1902 at 4½ per cent. on capital and 1½ per cent. sinking fund; the gas company is to have the first £525 of profit; beyond that the town and the gas company divide equally. The Ganz alternating system is used, with overhead conductors from the works to the town, a distance of 1¾ miles, and underground in the town.

Bimetallic Wires.—The system of bimetallic telegraph and telephone wires of copper on steel, mentioned in our last, is, we now learn, not the Durand, but the Martin system; and, according to the *Bulletin International de l'Electricité* for August 25, the French Administration of Posts and Telegraphs, after full tests, have found a favourable report, and an order for wire of 3mm. diameter has been given. This is for the line between Paris and Saint-Quentin—a total requirement of some 280 miles.

Post Office Telpher Line.—The longest telpherage line in the world is to be opened this month in South America. This overhead electric railway will be 186 miles long, and will connect Buenos Ayres with Montevideo. Its object is to allow of travelling letter boxes to be dispatched every two hours between the two cities. The line will cross the La Plata estuary in that part where it is 19 miles wide. The two wires there will be supported on either side of the river by two towers nearly 270ft. high.

Edison and Sprague.—The Edison General Electric Company, of America, has issued a circular informing its patrons and others that the business of the United Edison Manufacturing Company and the Sprague Electric Railway and Motor Company have been transferred to the Edison General Electric Company, and that the business heretofore conducted by the two former companies will hereafter be conducted by the Edison General Electric Company, which will have district offices at New York, Chicago, Denver, San Francisco, Portland, Toronto, and New Orleans.

Edinburgh Exhibition.—The Lord Provost, magistrates, and Town Council of Glasgow paid an official visit on Tuesday to the Edinburgh Electrical Exhibition. They were met at the exhibition by a deputation of the Edinburgh Town Council, and afterwards conducted by the executive committee round the exhibition and grounds, including a trip on the telpher railway, a sail in the electric launches on the Union Canal, and a visit to the other extra attractions. In the evening the visitors were entertained to dinner by the executive in the Royal dining-rooms.

Omnibuses.—Our readers will be interested to hear that the Brush Electrical Engineering Company, Limited, have entered into a contract with the London Road Car Company for the supply of 60 omnibuses. These are ordinary omnibuses for horse traction, and will be constructed at the Brush Company's Falcon Works, Loughborough. Large extensions have been made at these works to enable the company to cope with increasing demand for their steam-engines, tramcars, and omnibuses for electric or other traction, rolling stock, and electrical machinery, and apparatus of every description.

Electricity as a Hair Destroyer.—A correspondent writes for further information on this subject. A letter sent through the post has been returned owing to "insufficient address." Quite recently we referred to a letter in the *Times*, in which a lady gave her experience. The result in her case was unsatisfactory and costly. We should advise our correspondent to have nothing whatever to do with advertisers who promise to effectually and permanently remove hair from the face by electrical methods. These advertisers are generally utterly ignorant of electrical science, and bolster up their practice with actual falsehoods.

Submarine Ball.—A curious kind of submarine torpedo has been devised and tested in Italy. It is in the form of a large hollow ball, with room for several men inside. Arrangements are made for discharging projectiles, and also for picking up submerged articles by means of grapnels let down from the inside. This submarine ball

can be raised, lowered, and propelled under the surface of the water, and rotated on its own axis, and the tests recently made proved very satisfactory. The energy for propulsion and steering in the original was all done by hand work from the inside. It is proposed to construct another and larger on the same pattern, in which the power will be derived from electric motors.

Spanish Cables.—The Spanish Minister of the Interior, by a notice dated the 18th inst., has invited tenders for the construction and laying of telegraph cables between Spain and the Spanish possessions on the north coast of Africa and to Tangier. Seven sections of a total length of about 332 miles will be required. The maximum payment to the contractor will not exceed about £160 per mile. These tenders are to be addressed in sealed covers to the Director of Posts and Telegraphs, Telegraphic Department, No. 18, Calle de Claudio Coello, Madrid, and must be sent in within 30 days from the 18th inst. The conditions (in Spanish) may be seen at the Commercial Department of the Foreign Office, London, between the hours of 11 and 5.

Chester.—The electric light question is now a prominent one at Chester. At the last meeting of the Town Council the Watch Committee recommended that the Bill confirming the provisional order, having received Royal assent, be referred to the committee to report as to the course most advisable for putting its powers into execution. Alderman Frost recommended the Council to enquire of other towns where electric lighting was in existence and see if it paid. It was stated that the matter was tentative, that the committee did not intend to hurry the Council into hasty steps, and that the recommendation was one to glean information. The recommendation was agreed to, and the Town Council may therefore now be considered as on the look out for the best information.

Electric Lamp as Bedfellow.—"We can give a point to New York people about getting their money's worth out of these little movable electric-bulb lights," said a visiting Idahoan the other day to a reporter of the New York *Times*. "Out our way we take them to bed with us. For keeping one comfortable on a cold night they are as good as a roaring fire in a room. Rubber bags, tin boilers, and other devices for holding hot water get cold. With the thermometer 40deg. below zero, as we often have it in Idaho for long stretches at a time, these old-fashioned arrangements would freeze before morning. But the electric bulbs keep one snug and warm all the time. When I begin to get ready for bed I put the light between the sheets. By shifting it about every little while it takes the chill from the bed by the time I am undressed. As I slide in I push the light down with my feet, and usually fall asleep with it there."

Telephone Management.—We are informed that Mr. A. R. Bennett, who has been general manager to the National Telephone Company in their northern districts for nearly eight years, has resigned his appointment, and will cease to administer the company's affairs in Scotland at the end of October. Since the amalgamation last year of the three principal telephone systems the operations of the extended National Company, which has little in common with the old National except the name, have been chiefly directed by gentlemen who were directors of the old United Telephone Company, which worked London, and of the old Lancashire and Cheshire Company. Mr. Bennett, who had previously been unable to agree with the policy of the new board on several important points, determined towards the end of July, on an event of an extraordinary nature occurring which rendered cordial co-operation in the future impossible, to sever his connection with the company at the earliest possible date.

Ferranti Tests.—The Ferranti mains have been going down in the Strand this last week, and tests are being continually made along the whole line. The lengths to Deptford are approaching completion, and five miles of main has now been under test. Over a mile has been tested at the full pressure in one length, and current to a small amount, sufficient that is to actually light lamps through it, has been sent along this length. The tests adopted have been very elaborate and careful, and comprise graduated tests with potentials of 10, 20, 100, 500, 1,000, 2,500, and 10,000 and 20,000 volts. The tests with from 4 to 10 volts are simply for continuity, and the intermediate pressures are for testing cable to cable, outer cable to sheathing, cable to earth, and so forth. Then the two conductors are tested with 1,000 volts between themselves; then the full circuit pressure at Grosvenor, 2,500; again with full pressure now used from Deptford, 5,000; then with full proposed pressure, 10,000; and lastly, with a huge drayful of transformers at 20,000 volts. The work is progressing rapidly; during the last week four times the number of workmen has been put on.

Estimates for Lancashire Villages.—At its last meeting the Billinge Local Board had under consideration the question of lighting the streets during the winter months. The chairman (Mr. Heald), who introduced the matter, expressed the opinion that theirs was the only township in Lancashire which is not lighted in the winter; and said that wherever they went out of the village they found gas or some substitute for it. The only objection to the adoption of public lighting was that they had done without it so long, and could dispense with it a little longer. After some discussion on the respective merits of oil and electricity, it was decided to obtain an estimate for the electric light, on the condition that the estimate was supplied free of cost. At Ince, in the same neighbourhood, a discussion arose at the Local Board meeting on the question of lighting the street lamps. One member expressed opinion that the practice of leaving the lamps unlighted was disgraceful. The lamps should either be lighted or the lamp-pillars, which under the existing conditions were a source of danger, should be removed. It was decided to light the lamps every night for the present, pending a full consideration of the subject.

City Guilds Institute.—The "Programme of Technological Examinations," just issued by the City and Guilds of London Institute, show a continuous and important extension in the direction of true technical education. The programme itself is becoming quite a large book of some 230 pages. The first part comprises very full particulars to intending students of the various courses and the text-books to be studied. The second part contains a long list of teachers registered as able to hold classes for the technological instruction. The last hundred pages contain the papers set in examination for 1890. We notice these papers are admirable from the point of view of requiring a practical knowledge from the student; for instance, in the ordinary grade the question is put requiring the sketch of arrangement of gas-engine plant and accumulators for 100-volt lamps, and generally any theoretical question is required to have sketches or description of some actual apparatus. In the honours grade the efficiency of dynamo is dealt with, insulation test of house

installation, the chemical actions of the E.P.S. cell, process of electric welding, sketches of electric meter for alternate and direct current, calibrating volt and ammeters, arrangements for overhead tramway transmission of power. A list, on page 13, is given of professors in various colleges whose certificates will now be accepted as evidence of knowledge in the necessary science subjects.

Cable Testing.—We well remember the absorbing interest some years ago—far transcending that of a novel—of the little book describing the laying of the first Atlantic cable by Cyrus Field and his helpers. An article on "Cable Laying," in *Cornhill* for September, by a writer who prefers to keep his name unknown to the public, has a true taste of this same strain of human interest in the actual operation of laying the submarine cables. The fitting and arrangement of the "Silvertown" is sufficiently described for an untechnical person to follow the routine of cable laying which is there interestingly given—the sounding for the route, the coiling of the cable in the immense hold, the erection of the cable hut, and the landing of the end, the running out of the cable, and the delicate and unobtrusive testing continually kept up in the little room amidships, and then the exciting period of bringing up the ship, whose momentum alone would carry her a mile, just at the right time to buoy the cable end in mid-ocean. "Eighteen coils in the hold. 'Go slow!' Nine. 'Stop her!' Three...two...one. 'Half speed astern.' End off the drum, sir! 'Stop her! Down with the breaks!' The cable crawls along, and the end is stopped halfway between drum and stern sheets." The reminiscences will fill old cable hands with reflected excitement and expectation, and will give to the general public an admirable sketch of the process of laying out submarine cables.

Primary Batteries for Traction.—While the electrical world is anxiously watching the race between storage and direct-driven cars, a correspondent of the *Moniteur des Tramways* is in ecstacy at the behaviour of a primary battery which has achieved wonders when fitted for driving an electric tricycle, and he looks to see it applied more usefully as the motive power on the Lyons tramways. At Asnières, the account runs, for the last few weeks, the curious spectacle has been seen of a large tricycle driven by an electric motor supplied from the nine cells of a battery of a new kind made by the inventor, a M. Million. The motor is geared to the large wheels, and by means of levers the motor can be driven backwards or forwards, and the speed of driving changed according to the gradient. The head lamp is a small Edison lamp lighted from the same battery. The Million battery is remarkable for the regularity and strength of the current during a long discharge. The nine elements drove the tricycle mounted by a man a journey of 45 miles in eight hours on an ordinary road for a total cost given as four francs (3s. 3d.). This experimental tricycle is not furnished with pedals, though when made for sale these will also be added, and can be used on stiff inclines, "although," says the writer of this account, "we saw on Sunday the apparatus in question mount, as fast as a man could walk, a hill of 12 per cent. gradient, and 300 yards long, several times running, to the great astonishment of numerous bicyclists and tricyclists who, to pass from the banks of the Seine to the heights of Courbevoie, were pushing their machines before them." An engineer of one of the large constructional works of the neighbourhood witnessed these evolutions, and it is understood he intends at once to utilise these batteries for electric tramway traction. A specimen is expected to be shown working on a sample line at the exhibition at the Palais de l'Industrie, and "the town of Lyons will not, we also know, wait very long before possessing a motor of this type."

Thunderstorms and Milk.—"In our long experience," says a writer upon the subject of milk and thunderstorms, "we have never had any milk affected by the ozone either in shallow pans or deep pails, and are of opinion that the heat of the air preceding the thunderstorms is more directly the agent in the souring of the milk than the ozone that may exist in the air after the storm is passed. Carefulness to maintain a proper temperature by closing doors against the outer atmosphere will be a means of safety." From experiments by an Italian, Prof. G. Tolomei, however, published in the *Times*, it seems that the ozone is the active agent in acidifying the milk. He experimented with electricity on fresh milk in three different ways—first, by passing the discharge of a Holtz machine between two balls of platinum inserted nearly two inches apart in a bottle containing milk; second, by sending a battery current between two strips of platinum at the bottom of a U tube holding milk; and, third, by subjecting milk in a test tube to the action of a strong battery current through a silk-covered copper wire wound spirally round the tube. In each case the acidulation was delayed, not hastened, and took place on the seventh, ninth, and sixth days respectively; while milk not treated was manifestly acid on the third day. The professor next tried the effect of ozone, and found it distinctly acidifying. In one case the surface of a quantity of milk was brought close under the two balls of a Holtz machine, and the milk soon became acid in consequence, the sooner if the discharge was silent (not explosive), in which case more ozone is formed. In another case ozonised oxygen was made to bubble up through a quantity of milk, which in a few hours was completely acid and soon coagulated spontaneously. Prof. Tolomei is of opinion that oxygen probably also promotes lactic fermentation (a point which has been disputed). If milk keeps longer in wide, shallow vessels, that is probably due, he thinks, to the cooling produced by evaporation, which is favoured by a wide open surface.

Precautions in Stations.—From time to time we see an account of an accident in an electric light station to an employé of the company, who from some negligence receives a shock more or less dangerous, and occasionally fatal. Such a case is distinctly different from that of an outside person accidentally getting a shock, but it is right to say that the precautions which are necessary outside should be really just as necessary inside. It is useless (to the man) to say afterwards, as is sometimes done, that he knew the dangers and should have avoided them. Danger from electric light must be just as much guarded against as that from moving belting in factories, and more so, for it is invisible, and it should be rendered practically non-existent. We remember in a station (now, we believe, entirely altered) that the 2,000-volt terminals stood within an inch or two of each other, and quite bare to the air. The workman should and would avoid these; but an accidental push or slip of a ladder might cause a short circuit. Again, the workman might be perfectly aware of the danger, but another person may not. It is perfectly correct to say that no one but the workmen should be allowed in the stations, but, as a fact, we find they are so allowed occasionally, even in the best regulated stations. Clerks, new to the position, may presume on their place and wander in; or consequential visitors are not uncommon, and in

cases we have in our mind it would not be impossible that the want of precaution might fail. We very well remember the answer of a well-known electrical engineer of one of our large companies saying, in reference to the question, that such persons ought not to come inside, and "if they were so foolish as to meddle and were killed, so much the better—the world would be well rid of them"; but this kind of off-hand argument would have a very poor show in practice. It would be well if those in charge of electric installations, having in view the invisibility of the force, were to periodically look round to see if there exist means by which accidents could possibly happen, save with determined effort and technical knowledge of the means of so doing, and if so, to report and change it.

Overhead Conductor Tramways.—The two things that naturally strike an American visitor to England are the almost entire absence of arc lighting in the streets of London and the non-existence everywhere of the electric tramways, with their branching overhead conductors, now almost universal in the States. The one we hope to see shortly changed, and the streets of the City should be glowing with Brush and Thomson-Houston lamps by the next winter season. For the other, we may never see the widely-spread use of overhead conductors for tramcars in English towns, nor, perhaps, greatly desire to do so, as the ingenuity of electrical engineers is keenly exercised in evolving a satisfactory underground system of tramcar supply. But it is interesting to remark that, after long waiting, an overhead conductor system is actually running at the present time at the Edinburgh Exhibition, the first of its kind, we believe, in the United Kingdom. This electric railway, with its "broomstick"—ridden, as Oliver Wendell Holmes has just quaintly expressed it, by "invisible witches"—long reaching up to the slender aerial string wire, is now being run by the Electric Engineering Corporation, the official and other difficulties to which we have briefly alluded having been overcome. The car is named the "Clerk Maxwell," and is a handsome specimen of both electrical and carriage workmanship. Just how far we shall use the overhead system in England seems to be a very debateable point. One writer of influence, whose experience is practical and unique, has stated that it is impossible to get local authorities in England to consent to overhead wires for tramways. On the other hand, the officers to a certain large proposed company have stated definitely that the wayleaves for tram lines in various parts of the kingdom—in Ireland, near Manchester, and in other parts of England—have been obtained, and that electric tramways on this system could certainly be erected and run were there anyone to undertake the work. If there is any likelihood and possibility of this direct mode of electric traction being adopted, the existence of the line mentioned may possibly, now that it can be seen and critically inspected, result in further endeavours to introduce the "broomstick" cars What with large orders for accumulator cars now in hand, with two or three closed-conduit systems in practical shape, and the genuine overhead system at last at work, we may reasonably look for extensions in one shape or another of electrical railway work in England.

Power Required for Electric Railways.—Some tests are published in the *Electrical World* for August 16 by Mr. G. D. Hulett, taken by means of a recording ammeter on the Thomson-Houston line at Syracuse, N.Y. The line is four miles long and is worked by seven cars. The diagrams taken show an extraordinary variation on the magnitude of the total current and great rapidity in these changes. The current flowing out of the station would vary in a few seconds from zero to 100 or even 150 amperes. The starting current for four cars, started simultaneously, remained at 87 amperes for some five minutes. The mean horse-power computed from readings when the needle was fairly steady was 34·1 and 32·3 e.h.p. respectively. The efficiency of the station, taking simultaneous ammeter, voltmeter, and engine indicator readings, was 62·8 per cent., which was considered good, as double the cars might have been run without the extra engines. The highest was 82 per cent., but was often 40 per cent., and even if run full it is considered doubtful if over 75 per cent. could be obtained. The efficiency of the line from simultaneous station and line voltmeter readings was 91 per cent. The efficiency of the cars was more troublesome matter, and we are not sure that we follow the author in his remarks. "The practice," he says, "in the Thomson-Houston system is to throw out all the resistance as soon as practicable after starting, and consequently fully four-fifths of the entire distance is covered with the motor at its maximum efficiency. This was certainly true here at Syracuse, where long runs were made. The method adopted was to find the maximum efficiency of an average car, with the external resistance entirely thrown out by *obtaining the work* necessary to cover 350ft. upon the level track, and the same distance upon a grade averaging 5·76 per cent." We have italicised the point that does not seem clear. How was the amount of work necessary obtained? If by taking an engine, or another car, and drawing the idle car, it would give the result, but it is not so stated, and, indeed, these details are just the ones most desired. However, by combining the results, whatever they were, the author obtained an efficiency of 75·8 per cent.; "which," he says, "shows up very well for the motors, when we recollect that some 10 per cent. is consumed in the gearing." The efficiency with various resistances was also measured or computed, and as result in the present case 65 per cent. was taken as mean efficiency. The efficiency of the entire system was therefore, taking the product of the efficiencies of station, line, and cars, $62·8 \times 91 \times 65 = 37$ per cent. A total efficiency of 25 per cent. had been found at Lafayette with slow Corliss engines and shafting, and thus the advantage of quick-speed direct-driven dynamos is argued. The demand was heaviest at 8 to 8.30 in the evening, with decided drop from 12 to 2, but, on the whole, was moderately constant from 8 a.m. to 9.30 p.m. Coal consumption is given as 4,800lb., and average horse-power for the day 51·4; hence coal per indicated horse-power was 5·3lb., and per electrical horse-power 8·4lb. The cars ran 98 miles per day, so the electrical horse-power hours per car mile is ·82. One point to notice is that the curves consumed more power than the uphill inclines; the curves should be kept lubricated. The mean station voltage was 487, varying from over 500 down to 470. The greatest current observed was 225 amperes, and 200 was several times reached; but in all these cases the large currents held only a few seconds before a drop occurred. It will be noticed in the above that the total efficiency—37 per cent.—is small, and the knowledge of figures such as these reduces the rivalry between direct and storage systems more and more simply to one of comparative first cost of plant and length of life in the plates. It will be most interesting to compare similar authentic figures from the accumulator cars.

DYNAMO TESTING.

(Concluded from page 153.)

In the actual experiments performed at Messrs. Mather and Platt's works on February 27, 1886, the machines used were two Edison-Hopkinson shunt-wound 6½ unit dynamos, designed to give 320 amperes at an E.M.F. of 110 volts. The shunts for both machines were taken from the brushes of the generator, and in the field-magnet circuit of the motor a variable resistance was introduced, so that its magnetic field could be weakened and the work done by it varied.

The main circuit led through a resistance, R_M, very small, ·0058 ohm, and the current flowing through was measured by noting the difference of potential between the terminals of the resistance A and B, $\frac{E}{R}$ being, of course, equal to C. This difference of potential was ascertained by leading it through a variable resistance and balancing the E.M.F. of a Clark's standard cell against a known part of it. In their experiments they used 2,220 ohms. The E.M.F. of a Clark's standard cell being 1·453 volts, the difference of potential between A and B may be expressed:

$$\frac{1{\cdot}453 \times (2{,}220 + \text{rest of resistance})}{2{,}220}.$$

Three tests were made: First, the machines were run without their fields being excited; this gives the mechanical losses in the machines.

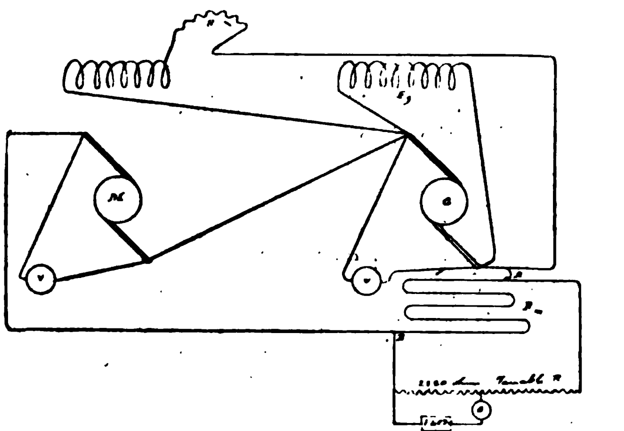

FIG. 5.—G, Generator or Dynamo; M, Motor; V V, Voltmeters; F m, Field Magnets, Motor; F g, Field Magnets, Dynamo.

They were next run with their fields separately excited; the extra loss here denotes that due to eddy currents and persistent magnetism in the armature. The connections were then made as shown, and when 358 amperes were flowing through the motor the power transmitted by the belt was 8·85 h.p.

The machines are working at full load; we know the total amount of loss; we can calculate the electrical losses in each machine, as we know both the current flowing and the resistance; and we also know the loss due to mechanical friction, which, as the machines are similar, we may call the same for either, and halve the very small fraction of power left.

The commercial efficiency of the machines tested were 92·5 as dynamo, and 92·6 as motor.

Soon after the publication of these tests various methods based on the same principle were proposed.

Major Cardew stated that he was in the habit when testing dynamos for the War Department of taking two machines of the same size and output, and coupling them together either with a belt or rigid connection, so that one worked as a motor and drove the other as a dynamo. Current from an external source was then passed through the motor, its amount and E.M.F. being carefully noted. The current generated by the dynamo was run through resistances and carefully measured on the same instruments. The loss in the two machines was thus ascertained, it being the difference between the two amounts, and the machines being similar it was divided equally between them.

Lord Rayleigh about the same time suggested that accumulators might be used to supply what extra power was needed to make up for the loss. Messrs. Trotter and Ravenshaw shortly afterwards devised a method in which three dynamos were used, not necessarily of the same size and output, the only condition being that the output of any two joined in series must be greater than the third.

Fig. 6 shows how they proposed to arrange the machines. A is the dynamo under test; it is used as a dynamo in the first instance, connected in series with the dynamo C, driven from some external source. The current generated by A and C is used to drive B as a motor, which is the motive power for dynamo A. The electrical energy supplied to the motor is measured, and also the amount generated by the dynamo A. From these the combined efficiencies of A and B are calculated.

Similarly, B, C, and A are coupled up and tested, and C, A, and B. From the three combined efficiencies the separate values for each dynamo may be obtained thus:

Let A, B, and C be the three machines, and e_1 the commercial efficiency of A, e_2 of B, and e_3 of C; then using the symbols—V^1, volts generated by dynamo under test; V, volts utilised in driving motor; C, current.

When A is the dynamo under test, B acting as motor, and C as supplementary dynamo, $E_1 = \frac{V^1 C}{V C}$ = efficiency of A and B coupled together $= e_1\, e_2$.

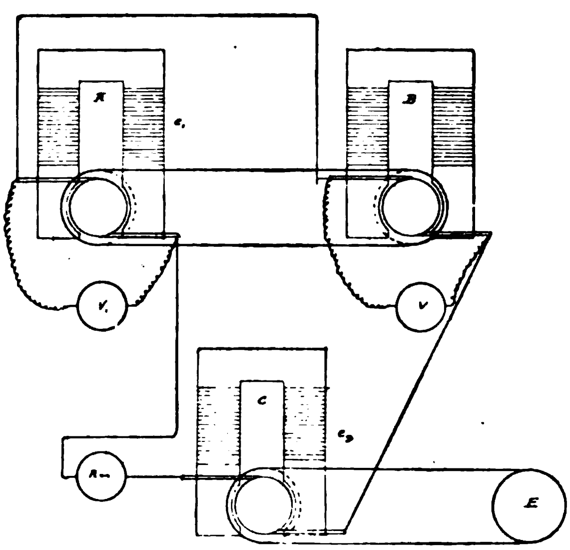

FIG. 6.

When B is the dynamo under test, C the motor, and A the supplementary dynamo, $E_2 = \frac{V_2{}^1 C_2}{V_2 C_2}$ = efficiency of B and C coupled together $= e_2\, e_3$.

When C is the dynamo under test, A the motor, and B the supplementary dynamo, $E_3 = \frac{V_3{}^1 C_3}{V_3 C_3}$ = efficiency of C and A coupled together $= e_1\, e_3$.

$\therefore e_1$ is a factor in E_1 and E_3,
e_2 „ „ E_1 „ E_2,
e_3 „ „ E_2 „ E_3,

and

$$e_1 = \sqrt{\frac{E_1 E_3}{E_2}},$$

$$e_2 = \sqrt{\frac{E_1 E_2}{E_3}},$$

$$e_3 = \sqrt{\frac{E_2 E_3}{E_1}},$$

It will be noticed that this method also assumes that the efficiency of a machine working either as dynamo or motor is the same.

Mr. Swinburne's proposal only involves the use of one small dynamo in addition to the one under test. The electrical losses he calculates, knowing the output at full load and the resistances both of the field-magnet coils and the armature. The remaining sources of loss he classes as

stray power, and determines it thus. He deduces from the armature resistance and full output what is the loss of E.M.F. in the armature, and adds it to the terminal E.M.F. He then drives the dynamo as a motor at that terminal E.M.F., taking the current from the small machine. As the dynamo is doing no external work a small current is sufficient. If it is shunt-wound, resistance is introduced into the field-magnet circuit until the speed is the same it is normally driven at. The amount of current flowing is then carefully measured, and also the terminal E.M.F. C E, the product of the two, is the amount of electrical energy, expressed in watts, we must spend on the machine in overcoming friction of all kinds. If this is added to the electrical losses, the commercial efficiency can be easily figured out.

These are a few of the various methods that have been proposed for dynamo testing. They have been, and are being daily, modified to suit varying requirements. They may, however, be absolutely relied on for accuracy; and, if need be, electrical engineers may now repay their old debt with interest, and calibrate the mechanical engineer's dynamometer with his own electrical instruments.

THE EDINBURGH EXHIBITION.—XIV.

In a neat case at stand No. 83, Mr. James White, of Glasgow, shows Sir William Thomson's new standard electric instruments.

each movable ring is in the horizontal plane nearly midway between the two fixed rings which act on it. The current goes in opposite directions through the two fixed rings, so that the movable ring is attracted by one of the fixed rings and repelled by the other. The position of the movable ring equidistant from the two fixed rings is a position of minimum force, and the sighted position, for the sake of stability, is above it at one end of the beam and below it at the other, in each case being nearer to the repelling than to the attracting ring by such an amount as to give about $\frac{8}{10}$ per cent. more than the minimum force.

In the balance instruments to measure alternate currents (which may be also used for direct currents) of from one ampere to 600 amperes the main current through each circle, whether of one turn or of more than one turn, is carried by a wire rope of which each component wire is insulated by silk covering, or otherwise, from its neighbour, in order to prevent the inductive action from altering the distribution of the current across the transverse section of the conductor.

The balancing is performed by means of a weight which slides on an approximately horizontal graduated arm attached to the balance; and there is a trough fixed on the right-hand end of the balance into which a proper counterpoise weight is placed, according to the particular one of the sliding weights in use at any time. For the fine adjustment of the zero a small metal flag is provided, as in an ordinary chemical balance. This flag is actuated by a fork, having a handle below the case outside, as shown in the

Fig. 1.—Sir William Thomson's Balance.

The standard direct-reading electric balances are founded on the mutual forces, discovered by Ampère, between movable and fixed portions of an electric circuit. The shape chosen for the mutually-influencing portions is circular, and each such part is called for brevity an ampere ring; or sometimes simply a ring, whether it consists of only one turn or of any number of turns of the conductor.

In each of the balance instruments, except the kilo-ampere balance, each movable ring is actuated by two fixed rings—all three approximately horizontal. There are two such groups of three rings—two movable rings attached to the two ends of a horizontal balance arm pulled, one of them up and the other down, by a pair of fixed rings in its neighbourhood. The current is in opposite directions through the two movable rings to practically annul disturbance due to horizontal components of terrestrial or local magnetic forces. In the kilo-ampere balance the whole current passes through a single fixed ring and divides through two halves of a movable ring, which are urged one up and the other down by the resulting amperian force.

In all the instruments the balance arm is supported by two trunnions, each hung by an elastic ligament of fine wire, through which the current passes into and out of the circuit of the movable rings or ring.

In all the balance instruments, in which the movable ring is between two fixed rings, the mid-range position of

drawing, Fig. 1. To set the zero, the left-hand weight is placed with its pointer at the zero of the scale, and the flag is turned to one side or the other until it is found that, with no current going through the rings, the balance rests in its sighted position.

To measure a current, the weight is slipped along the scale until the balance rests in its sighted position. The strength of the current is then read off approximately on the fixed scale (called the inspectional scale), with aid of the finely divided scale for more minute accuracy. Each number on the inspectional scale is twice the square root of the corresponding number on the fine scale of equal divisions.

The slipping of the weight into its proper position is performed by means of a self-releasing pendant, hanging from a hook carried by a sliding platform, which is pulled in the two directions by two silk threads passing through holes to the outside of the glass case.

Four pairs of weights (sliding and counterpoise), of which the sledge and its counterpoise constitute the first pair, are supplied with each instrument. These weights are adjusted in the ratios of 1 : 4 16 : 64, so that each pair gives a round number of amperes, or half-amperes, or quarter-amperes, or of decimal subdivisions or multiples of these magnitudes of current on the inspectional scale.

The useful range of each instrument is from 1 to 100 of the smallest current for which its sensibility suffices. The

ranges of the different types of this instrument regularly made are—

I. Centi-ampere balance :	from	1 to 100 centi-amperes.
II. Deci-ampere „	„	1 to 100 deci-amperes.
III. Deka-ampere „	„	1 to 100 amperes.
IV. Hekto-ampere „	„	6 to 600 „
V. Kilo-ampere „	„	25 to 2,500 „
VI. Composite „	„	·02 to 500 „ and from 100 to 25,000 watts (at 100 volts).

The following table shows for each type of instrument the value per division of the inspectional scale corresponding to each of the four pairs of weights :

	I. Centi-amperes per division.	II. Deci-amperes per division.	III. Amperes per division.	IV. Amperes per division.	V. Amperes per division.
1st pair of weights	·25	·25	·25	1·5	5
2nd „	·50	·5	·5	3·0	10
3rd „	1·0	1·0	1·0	6·0	20
4th „	2·0	2·0	2·0	12·0	50

The fixed inspectional scale shows, approximately enough for most purposes, the strength of the current; the notches in the top of the aluminium scale show the precise position of the weight corresponding to each of the numbered divisions on the fixed scale, which practically annuls error of parallax due to the position of the eye. When the pointer is not exactly below one of the notches corresponding to integral divisions of the inspectional scale, the proportion of the space on each side to the space between two divisons may be estimated inspectionally with accuracy enough for almost all practical purposes. Thus we may readily read off 34·2 or 34·7 by estimation with little chance of being wrong by one in the decimal place. But when the utmost accuracy is required, the reading on the fine scale of equal divisions must be taken, and the strength of current calculated by aid of the table of doubled square roots supplied with each instrument given out.

The centi-ampere balance, with a thermometer to test the temperature of its ampere rings, and with platinoid resistances up to 1,600 ohms, serves to measure potentials of from 10 volts to 400 volts.

CONSTANT OF THE CENTI-AMPERE BALANCE WHEN USED AS A VOLTMETER.

Weight used.	Resistance in circuit.*	Volts per division of fixed scale.
Sledge alone	400	1·0
„	800	2·0
„	1,200	3·0
„	1,600	4·0

* Including resistance of the instrument, which is about 50 ohms.

If the sledge and the second weight is used the constants will be double of those noted above.

A set of four sliding weights, of which the carriage constitutes one, is supplied with each instrument. The carriage is fitted with an index to point to the movable scale, and is intended to remain always on the rail. One or other of the weights is to be placed on the carriage in it in such a way that the small hole and slot in the weight pass over the conical pins. The weights are moved by means of a slider, which slides on a rail fixed to the sole-plate of the instrument and carries a pendant with a vertical arm intended to pass up through the rectangular recess in the front of the weight and carriage. The slider and weight are shown in position in the figure. The slider is moved by silk cords which pass out at the ends of the glass case. When the cords are not being pulled for shifting the weight, their ends should be left free so that the pendant may hang clear of the weight. When a weight is to be placed on or removed from the carriage, the slider should be drawn forward at the top until it is clear of the weight, and then pushed to one side until the weight is adjusted, when it may be replaced in position in a similar manner.

Cylindrical counterpoise weights with a crossbar passed through them are supplied for the purpose of balancing the sliding weights when they are placed at the zero of the scale. The sliding weight should be placed so that the index of the carriage points to the zero of the scale, and the proper counterpoise weight should be placed in the trough, fixed to the right-hand end of the beam, with its crossbar passing through the hole in the bottom of the trough. The flag which is attached to the cross trunnion of the beam should then be turned by means of the handle projecting from under the sole-plate until the index on the end of the movable scale points to the middle one of the five black lines on the fixed scale opposite to it. Care must be taken when making this adjustment that the fork which moves the flag is not left in contact with it, as this would impede the free swing of the beam. The fork should be turned back a little after each adjustment of the flag, and when the flag is being adjusted it is better to watch the flag itself, and make successive small adjustments until the beam stands at zero, than to make successive trials by pushing round the handle while watching the position of the index.

If the ligament has stretched since the instrument was standardised, the index at one end of the movable scale will be found to be below the middle line on its vertical scale when the index at other end is correctly pointing to the zero position. The error so introduced would be a small one, but it may be easily put right by slightly loosening the screws fixing the pillared frame which supports the movable beam to the base-plate, and raising it by slipping one or two thicknesses of paper below it until the indices simultaneously point to their zero position.

In using the centi-ampere balance as a voltmeter, when great accuracy is required, care must be taken that the effect of change of temperature in changing the resistance of the coils of the instrument, and of the external resistance coils, is allowed for; and in this use of the instrument it is advisable to employ currents such as can be measured by the lightest weight on the beam. When the instrument is to be used as a voltmeter, four resistances are provided, three of which are each 400 ohms, and the fourth is less than 400 ohms by the resistance of the coils of the instrument at a certain specified temperature. The smallest resistance is intended to be included by itself in the circuit when the lowest potentials are being measured, and in series with one or more of the others when the potential is so high as to give a stronger current than can be measured with the lightest weight on the beam. The correction for temperature is—for the copper coils of the balance about 0·38 per cent. por degree centigrade, and for the platinoid resistances about 0·024 per cent. per degree centigrade.

The composite balance is similar in form to the centi and deci-ampere balances, but the pair of fixed coils at one end of the beam are made of a rope of insulated wires similar to that used for the coils of the hekto-ampere balance. Separate electrodes are provided for the rope coils and for the fine wire coils. A switch which allows the movable coils either to be included in the circuit by themselves or in series with the fixed fine wire coils is attached to the under side of the sole-plate of the instrument. When the handle of the switch is turned to "Watt," the movable coils alone are in the circuit; but when the handle is turned to "Volt," both the movable and the fixed fine wire coils are in the circuit. The composite balance can be used as hekto-ampere balance, or as a wattmeter, or as a voltmeter.

To use the instrument as a centi-ampere meter or as a voltmeter the switch is turned to "Volt," and one or other of the weights marked $V.W_1$, $V.W_2$, $V.W_3$, used. The current flowing through the instrument is then to be calculated from the constant given in the certificate sent with the instrument. The volts on the terminals are calculated from the current in amperes and the resistance in ohms (including the anti-induction resistance, if any) in circuit. If V be volts, C current, and R resistance.

$$V = C R.$$

To use the instrument as a hekto-ampere meter the switch is turned to "Watt" and the thick wire coils inserted in the current circuit in such a way that the right-hand end of the beam is repelled up. Either the sledge alone or the weight marked W W is to be used in this case. A measured current is then passed through the suspended coils and the constants given in the certificate for the balance used in this way are calculated on the assumption that this current is, as there stated, 0·25 amperes. Any other current which is convenient in the circumstances may be used,

and if this current be C amperes the corresponding constant is obtained by multiplying the constant given in the certificate by C/·25 or 4 C. The current through the suspended coils may be measured by means of the instrument itself arranged for the measurement of volts. This may be done by first measuring the current which the difference of potential between the supply conductors of an electrical installation, or between the poles of a battery, causes to flow through the coils of the instrument and its external resistance, and then turning the switch to "Watt," and at the same time introducing a resistance into the circuit equal to the resistance of the fixed coils.

To use the instrument as a wattmeter one terminal of the fine wire coils is joined to one end of the anti-inductive resistance and the other terminal to one of the leads, the other end of the resistance being joined to the other lead. The thick wire coils are inserted in the main circuit. With the instrument thus joined up, the current through the suspended coils and the E.M.F. between the leads may be obtained, since the presence of the thick wire coil in the circuit causes no appreciable error; or the E.M.F. may be taken from the electrostatic voltmeter used on the circuit, and from its indications the current in the suspended coil circuit calculated. The watts are then to be calculated from the E.M.F. on the leads and the current through the thick wire coils by the formula

$$W = VC = cCR,$$

where c is the current in the suspended coil circuit, C the current in the thick wire coils, and R the resistance in the circuit.

FACTORY LIGHTING.

English millowners, unlike their foreign competitors, are apparently slow to avail themselves of the benefits of electric lighting, and theirs is the loss. To show the advantages of its use, the Blackburn Corporation, in the very centre of the Lancashire cotton industry, some time ago addressed a circular to various cotton manufacturers at home and abroad who use the electric light, for the purpose of obtaining definite information as to results of electricity compared with the use of gas. These, without exception, showed in favour of the newer illuminant. Thanks are due to this public-spirited local body, and their action has resulted in several new installations among the cotton mills of Lancashire. Still there is an inactivity among manufacturers as a body, which is probably due to the feeling of disinclination to change.

Many reasons could be given to further convince those who are favourably inclined towards the lighting of mills by electricity, and these reasons, already strong, become stronger in the cases where special goods are manufactured. It is well known that the making of certain coloured goods ceases with daylight; the blending of colours is practically impossible by gas light; the consequence is the worker has to throw aside an incomplete piece of work, which must be harmful, and take up another piece.

In order to obtain authentic information on the subject we have corresponded with owners in the North of England as to the results of the electric lighting. We were supplied by one firm with the annexed details. "The light is preferable to gas on account of the almost perfect immunity from fire, on account of the coolness and purity of light. The slightest differences of colour or shade are easily detected under the electric light, which could not possibly be done if using gas. Then, again, the pure state of the atmosphere has improved the stamina of the operative, which is a valuable consideration." This item, without any advocacy on our part, proves that electric lighting in factories is superior to gas.

The three distinct advantages claimed by one of our correspondents, who we may say has used the electric light for a long period, should have great weight in the consideration of owners of factories. It is a good deal to say that a mill is less likely to be destroyed by fire than it was under a previous system of lighting. As to the coolness and comparative purity of the air, it has been proved again and again by medical statistics that the stuffy state of factories is responsible for a good deal of the mortality and decay which is so prevalent among those whose lot it is to toil day after day at the looms. This may not be so strong a reason to employers as the previous one, but when we show that the improvement of the conditions under which employés labour must affect the quality and quantity of work done, it will have its due effect. As to the third advantage claimed, the making of coloured pieces under artificial light, it is a boon better appreciated by the maker than we can tell.

The question of cost, however, in all fairness must be allowed to be the first considered, though we must object to a comparison with the cost of gas. It would not be just to compare the figures of a year's electric lighting with a year's gas. It is most probable that considerably less was paid for the older illuminant, but are we not to reckon abstract advantages in the way of the improved condition of the operative? also the quantity of coloured pieces finished by the aid of the electric light. This should be placed to its credit, and as immunity from fire is obtained, that should stand for a good deal. Naked lights are always considered a source of danger, and by the use of electricity they are abolished.

The cost of maintaining electric light plant in a factory should be small. There are always in these places good mechanics at hand who, with the exercise of a little discretion, will speedily repair any slight breakdown. Steam power is on the premises, and very few engines are running at full pressure. With these and many other advantages, it should not be long before there is installed in most factories a good system of electric lighting, well repaying its owner for the trouble and expense entailed at the installation.

CORRESPONDENCE.

THE APPLICATION OF ELECTRICAL ENDOSMOSE TO THE TREATMENT OF GOUTY CONCRETION.

To the Editor of the Electrical Engineer.

Sir,—In view of the communication of Mr. Edison on the above subject made to the International Medical Congress at Berlin, I should feel obliged if you will grant me a little space to state that this form of electrical treatment has been in regular practice here for many months, and was brought from its experimental to its practical stage by Dr. Arthur Harries and myself some time before the experiment described by Mr. Edison.

The name given to this treatment by Dr. Harries, and adopted by the institute, is "Cataphoric Medication," and by this name it has been publicly mentioned on the following (and other) occasions:

November 5th, 1889.—At a lecture delivered here by Dr. Harries, on "The Physiological Action of the Continuous Current."

December 11th, 1889.—Letter in *Medical Press and Circular*, by Dr. Harries.

December 19th, 1889.—Address to City Guilds Old Students' Association, by H. Newman Lawrence. Published in *Electrical Review* of December 27th, 1889.

January, 1890.—Letter in *Whitehall Review*, by H. Newman Lawrence.

That Mr. Edison should interest himself in the matter, and that the Berlin Medical Congress should consider it of sufficient importance to be made public at its meeting, is very gratifying to this institute and its officers, who have for some time past been practising this important advance in electro-therapeutics which these great authorities appear to have only just thought of.—Yours, etc.,

H. Newman Lawrence, managing director.

The Institute of Medical Electricity, Limited, 35, Fitzroy-square, London, W., August 26th, 1890.

Prague.—The Municipal Council of Prague have granted a concession to M. Franz Krizik to establish an electric tramway between the Belvedere and the Baumgarten. This tramway will be running on the occasion of an exhibition which is to take place in Prague next year.

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THE BRITISH ASSOCIATION.

After a lapse of thirty-two years the British Association meets once more at Leeds. Out of the list of members given in the issue of the *Proceedings* for 1889, about one-tenth were members at the last Leeds meeting, though many of the most prominent members and active workers have passed away. The annual meeting of the association has a double function—on the one hand, it brings the scientific world together for a week's social intercourse; on the other, it provides time for verbal warfare, amusing and harmless enough in many instances, instructive in others, and extremely valuable in a few. Here the younger generation of *savants* are permitted to air their views to reporters, a few friends, and empty benches. These sham fights help them to overcome stage fright—prepare them for sterner criticisms when appearing before less mixed audiences. The townsfolk look upon the whole affair as a holiday. For the benefit of science they become associates or members, and patronise each section in turn for the first day, though ever after fighting shy of A and G. The stars in these sections have courses of their own which appeal little to the popular taste, while Sections E and F generally provide pabulum suited to their tastes. Let it be whispered, many who are compelled to remain in A or G would probably prefer to hear fewer papers, and to hear the subjects of these papers properly treated and discussed, rather than, as now, to have to get through a larger number of papers in the helter-skelter way that sometimes occurs. Say ten papers are down on the programme, it too frequently happens that the first or the first and second papers take up three parts of the time, while the other eight papers are crammed into the remaining quarter. We will, however, say of Section G that it is admirably managed. Almost without exception abstracts or copies of the papers can be obtained, rendering it simple for the audience to understand, and much easier for those connected with the press to report. Each section is generally fully reported by special papers, so that ofttimes the reading public, not attending the meeting, is in a better position to estimate the value of a man's paper than the audience before which it is read in haste. It is impossible to satisfactorily put two days' work into one, and although the number of papers may show the activity of scientific investigation, it is not creditable to the association to be compelled to hurry without an effort to digest. Another reform urgently needed is a break of a few minutes for luncheon. The day's sectional work lasts from 11 to 3 or 3.30. There is no break. One paper is read, discussed, and the next called on. The paper that you particularly want to hear is not the first nor the last, but the one that happens to come at the ordinary luncheon time. We would suggest an interval

of 15 minutes—about 1 o'clock—which would give about two hours for papers before and a similar period after the interval. It is not the officials that suffer, they arrange their "sentry go" admirably. But if grumbling at minor troubles is the order of the day there would be no end; it is better perhaps to look philosophically on all these matters, agreeing with Pope that:

"Whatever is is right."

It is not often possible to foretell the amount of interest a specific subject will create at the association, but during the past ten years or so electricity has played a very prominent part at these meetings. The two most important papers as yet known seem to be that of Prof. Ewing on "The Molecular Theory of Induced Magnetism," and that of General Webber on "Electrical Distribution"—the former will be read in Section A, the latter in Section G. A number of electrical papers are promised, but as we hope to give them fully in due course it is unnecessary to attempt to discount their value. There will, we are told, probably be a discussion on "Electrical Units," a subject to electricians, like the weather to the general public, always new and never exhausted. The set discussions are grand fun. Two tried warriors take opposite sides, and proceed to demolish each other and each other's theories in a gentlemanly manner. The "asides" and the interpolated ejaculations are worthy of the House of Commons; the final result being also very similar, agreeing—after an infinite expenditure of verbal energy—to differ.

Leeds is proceeding with the well-known hospitality of Yorkshire to provide for the comfort and convenience of the expected guests, and if there should be found something lacking in details, it will not be from the want of energy on the part of the hosts.

THE HOPKINSON DISCLAIMER.

The result of the judgment given by the Comptroller-General of Patents on the Hopkinson disclaimer suit, is practically against the brothers Hopkinson. The view taken by the Law Courts with regard to sweeping electrical patents seems to be setting against general claims, and however we may sympathise with inventors who would wish to reap the widest reward in royalties for what they consider a great discovery, yet it is distinctly to the benefit of the industry not to be so hampered. The present patent, 14,233, 1884, was one for an improved method of regulating induction coils, in which lamination of the closed magnetic circuit was an essential and novel part. Since that time great strides have been made with induction coils, and transformers in the present shape have been evolved. These in present practice use a laminated closed magnetic circuit, and if the patent could be shown to bear upon the present transformers, it would constitute the master patent for these necessary pieces of apparatus, now made by all makers of alternate-current systems. In the disclaimer, therefore, the words "for use in electric distribution," and corresponding claim, were sought to be inserted so that it would be clear that the claim referred to what is now known as transformers; sundry verbal alterations were also made, several other words referring to the new claim were added, and several claims were disclaimed. The verbal alterations of "control" for "contact," and "mutual" instead of "neutral" (induction coil) are allowed; as also is the alteration of the statement of the direction of lamination from "perpendicular" to "parallel" (to the lines of force), as evident from the description and drawings. But the insertion of the words directly referring to "electric distribution" are disallowed, and so also is the clearer claim thereby made. There were several opponents – the Electric Engineering Company (acting for themselves and several well-known firms), The Brush Electrical Company, Messrs. Siemens Bros., and Messrs. Johnson and Phillips. Not all were agreed in objecting to the minor alterations now allowed, but all were unanimous against the insertion or modification of the claim, and are, as seen, successful in their combined objections.

THE REPORT TO WIGAN TRAMWAY DIRECTORS.

It is often surprising how cleverly a judge picks out the salient points of a case which seems understandable only to experts. In other lines of life common sense and a fair acquaintance with business frequently leads investigators to a just conclusion. It is dangerous, however, for one who is not an expert to enter upon explanations of phenomena with which he is unfamiliar. A careful perusal of the report of the chairman of the Wigan Tramways to his co-directors on the Canning Town electric trams shows that, while it contains a good deal of matter that is worthy of all consideration, it also contains some weak points which a fuller knowledge of the subject would enable the reporter to pass over without remark. The summary shows at once his strength and his weakness. A general sweeping condemnation like his first conclusion ought never to be given. The loss after the accumulators are once in working order can be any percentage of the energy of recharge you please. In other words, the accumulator can at will be made to show a very great or a very poor efficiency. A report of this kind should certainly say something about the percentage of loss. Then number three is hardly correct. Accumulators do not require skilled labour to work them, though it might be held they require such labour to charge them; and again, it may be

doubted whether a little more knowledge would not modify the fourth conclusion. However, while it may be admitted that certain forms of accumulators do not stand shocks and bumps, why, in the name of all that's good, are accumulators of other types to be summarily condemned? It has been said that the electric tram work at Canning Town shows a profit. It has also been said, Yes, shows a profit when depreciation is not considered. Mr. Johnson is not the only one who would like to have actual facts and figures as regards depreciation. At the same time it must be remembered that, in order to obtain business, it may turn out this particular work was accepted at a much lower price than was necessary, or that might have been had for the asking. If Mr. Johnson requires exact information, why does he not go to such a man as Mr. Reckenzaun, who probably knows more than any other man living the capabilities of electric tramways. Get such an expert's opinion, and then compare his opinion with the practice on existing lines. He will tell you why many fail, and how simple is the remedy. Just as well condemn a cart because a pin or a spoke drops out, or a tire comes off. Thus Mr. Johnson's report may convince his co-directors, but it ought to convince nobody else, because it condemns that which is not necessarily common to all electric trams, and, in fact, is less in use than the non-self-containable system.

NOVELISTS' SCIENCE.

In a novel, entitled "The Snake's Pass," which is running its course through the pages of a number of newspapers, the author trespasses upon scientific ground. He describes the search after treasure by means of a magnet. This is how they search a bog.

"We have poles on opposite sides of the bog with lines between them. The magnet is fixed, suspended from a free wheel, and I let it down to the centre from each side in turn. If there were any attraction I should feel it by the thread attached to the magnet which I hold in my hand."

"It is something like fishing."

"Exactly."

This is the novelist's way of fishing for treasure. We suppose the treasure was placed in iron boxes. If in wooden ones, or jars, or bags, a magnet would not be of much service. However, at this point of the story nothing more remarkable has been discovered than the tire of a wheel. It is something to find a novelist dabbling in magnetism, that wonderful, that mysterious power which has so long guided the mariner in safety over the trackless paths of the ocean. The expert is engaged to find "iron" hidden in the ground. The ubiquity of electricity is astounding. Soon it will have made its mark everywhere and its use become so common that no curiosity will be aroused.

COMPARATIVE TESTS OF DIFFERENT ACCUMULATORS.

Although numerous results have been published of the best-known accumulators it has not been without interest to again undertake a series of simultaneous tests of different types of accumulators, so as to be able to compare them one with another, so far as such a comparison is possible. This work has been carried out by M. R. Kopp, and recently published in *La Lumière Electrique*. The following is a *résumé* of this work by M. Gaston Roux, translated from *l'Electricien* of August 23rd. This indicates simply the method followed in the experiments, the data relative to the accumulators tested, and the results obtained.

The researches were made principally upon the accumulators of the Oerlikon Works, Zurich; the Huber accumulator manufactured at Marly-le-Grand; the Julien accumulators made by the Société Electrique of Brussels; and the Tudor accumulators made by Messrs. Busche and Müller, of Hagen, Westphalia.

They were carried out at the physical laboratory of the Polytechnicum Confederatif of Zurich.

In all the tests the E.M.F. and the difference of potential were measured by means of a Wiedemann galvanometer, carefully calibrated, and of high resistance (20,000 ohms).

The current strength was measured by means of a tangent galvanometer with eccentric magnet. The resistance was calculated by the general formula, $r = \frac{E - e}{I}$. But the difference, $E - e$, at the middle of the discharge only attained some 100ths of a volt, so that considerable uncertainty attended this value. The charge was stopped when the E.M.F. ceased to sensibly increase, and the discharge was carried to the point when the E.M.F. fell to 1·85 volts.

Oerlikon Accumulators.—The tests were made on three distinct types of cells from the Oerlikon Works—one type of the old manufacture, one of the new gelatinous electrolyte, and a new type of liquid electrolyte.

The first being naturally less efficient than the two others, will not be further referred to.

The accumulator with liquid electrolyte was composed of seven positive plates and eight negatives, of the dimensions 14·5 × 14·8 cm., 0·6 cm. in thickness. These plates were disposed in an hermetically sealed ebonite box, having a space of 0·9 or 1 cm. between each plate. These accumulators were destined for the lighting of the night trains running from Zurich to Geneva.

The weight of the plates was 14·4 kilogrammes, and that of the accumulator filled, 20·4 kilogrammes.

Some 10 preliminary charges and discharges were first given; then the accumulator was overcharged and discharged to an E.M.F. of 1·90 volts. The density of the solution varied from 1·17 to 1·25. The charging current was about 18 amperes, and that of discharge was 14·5 amperes. The following are the results, calling

Q_c the number of ampere-hours given in charge.

Q_d the number of ampere-hours given back in discharge.

W_c the work in ampere-hours $\int e_c I_c dt$ expended during charge.

W_d the work in ampere-hours, $\int e_d I_d dt$ given back during discharge.

η_q the efficiency in quantity.

η_w the efficiency in energy.

No. of test.	Q_c	Q_d	W_c	W_d	η_q	η_w
1	135·92	130·31	303·9	255·0	95·9	83·9
2	138·65	123·69	310·1	242·7	89·2	78·3
3	137·57	125·79	308·7	254·3	91·5	79·5

The Oerlikon Works have now for some time been manufacturing accumulators with gelatinised electrolyte, obtained by mixing three volumes of acid of density 1·1 with one to three volumes of silicate of soda of density 1·2.

The mixture is poured into a mould and allowed to stand for a few minutes. Then it is cut into slices of the thickness of the space between the plates; these slices are placed between the plates and all empty spaces filled up.

The necessity has been found of keeping this jelly always moist by sprinkling it with water from time to time. Such an electrolyte has the advantage of not being liable to spill during transport, or upon the breakage of an accumulator, and it also retains the plugs and so prevents short circuits; but it presents the inconvenience of retarding diffusion and thus increasing the resistance, especially at the end of charge or discharge. This accumulator is also more quickly exhausted, and its useful capacity is therefore not so great.

The accumulator examined, type C, was of the same dimensions as the preceding type, but the plates were only 0·3 cm. thick. It contained 12 negatives and 11 positives at distances of 0·6 cm. apart. The weight of the plates was 12 kilogrammes, and the total weight of the accumulator 18 kilogrammes. The normal discharge of this accumulator is only seven amperes, probably on account of the slowness of diffusion. The final value of E was here taken as 1·8 volt.

The results of the tests made are given in the following table:

No. of test.	Q_c	Q_d	W_c	W_d	η_q	η_w
1	112·76	94·15	244·82	176·5	83·5	72·1
2	112·66	94·73	244·79	177·7	84·1	72·6

By employing a rate of discharge six or seven times greater, the efficiencies fell to 75·7 and 55·2 per cent.

The resistance of this accumulator varied from 0·003 ohm to 0·01 ohm.

Huber Accumulator.—The cell tested was of the portable type. It was formed of thin plates, so that the capacity per kilogramme of plate might be high. On the negative plates the squares of active material were pierced with circular holes of 0·2 cm. diameter, in order to increase the active surface.

The size of the plates was 15·5 × 16·7 × 0·3 cm.

The weight of the plates was 6·5 kilogrammes, and that of the accumulator complete 12 kilogrammes.

The intensity of the charging current was about 12·5 amperes, and that of the discharge current was 16 or 32 amperes.

The following results were obtained:

No. of test.	Q_c	Q_d	W_c	W_d	η_q	η_w
1	89·49	84·97	202·63	168·56	95	83
2	92·58	84·34	213·46	165·70	91	77
3	91·68	81·56	208·75	162·88	89	77
4	81·98	77·99	183·93	155·12	95	84

The resistance of the accumulator varied from 0·003 to 0·006 ohm, and the acid density from 1·19 to 1·126.

In other tests, when the discharge was carried to the farthest point instead of stopping at 1·85 volt, the efficiency was not sensibly modified.

Julien Accumulator.—The cell submitted to test was contained in a wooden box lined with lead. The plates, seven positives and eight negatives, measured 23 × 18·5 × 0·4 cm. The weight was 20 kilogrammes, and that of the whole cell was 33 kilogrammes.

The charging current was kept about 24 amperes, and that of discharge about 28 amperes.

The results obtained appear in the table herewith:

No. of test.	Q_c	Q_d	W_c	W_d	η_q	η_w
1	251·6	224·7	570·8	445·5	89·3	78·0
2	247·9	225·5	562·2	446·8	90·9	79·5
3	250·7	230·9	572·0	450·4	92·1	80·3
4	247·5	226·7	555·1	447·7	91·6	80·7
5	248·9	223·7	551·9	447·5	89·9	81·1
6	246·4	229·2	560·3	445·5	93·0	81·4

The resistance of the accumulator varied from 0·001 to 0·002 ohm, and the density of the acid from 1·24 to 1·15.

Tudor Accumulator.—The type of cell tested was that destined for stationary use, and the plates were therefore very thick. The cell contained five positives and four negatives. These measured 16 × 19 cm. The thickness of the negatives was 0·7 cm., and that of the positives 1·6 cm.

The weight of the plates, including the connecting pieces, was 25 kilogrammes; that of the cell complete was 38·9 kilogrammes. This accumulator had already been in service for several years.

The distance between the plates was sufficiently great to allow the plugs to fall without forming a short circuit. The tests made upon this cell are given in the following table:

No. of test.	Q_c	Q_d	W_c	W_d	η_q	η_w
1	98·05	92·29	214·07	179·10	94·1	83·7
2	100·10	86·15	218·56	168·42	86·0	77·0
3	91·34	84·65	197·20	164·35	92·7	83·3
4	93·84	86·95	205·63	171·78	92·6	83·5

The resistance of the accumulator varied from 0·002 to 0·003 ohm, and the density of the acid from 1·20 to 1·15.

COMPARATIVE TABLE OF EFFICIENCIES, CAPACITIES, USEFUL OUTPUT, AND WEIGHTS OF VARIOUS SYSTEMS OF ACCUMULATORS.

A. Oerlikon accumulator—liquid electrolyte. B. Oerlikon accumulator—jelly electrolyte. C. Huber accumulator. D. Julien accumulator. E. Tudor accumulator.

Comparison of Results.—Above is reproduced a table résuming the principal characteristic properties of these accumulators. The Tudor accumulator being of a type for fixed installations, its specific values are considerably lower than those of the other systems. It is to be regretted, concludes M. Roux, that M. R. Kopp has not indicated the useful capacity per square decimetre of active surface; this would have been a far more interesting factor than the capacity per kilogramme of active material. This value, although very little mentioned, is nevertheless one of the most interesting in accumulator statistics.

THE SANITARY ASPECTS OF ELECTRIC LIGHTING.*

BY W. H. PREECE, F.R.S.

The chief tendency of modern legislation in our British Parliament is to improve the environments of the human frame, so that we may live, and move, and have our being with greater health to the individual, and greater prosperity to the nation. The cleanliness of dwellings, the drainage of towns, the removal of filth, the suppression of nuisance, have not only been specified, but the inspection of the means to effect these objects and of their results are defined and insisted upon by Acts of Parliament. People often speak disrespectfully of our grandmotherly government, but at least in this region of domestic legislation the control it has exercised over the food we eat, the water we drink, the air we breathe, is of a true parental order, and deserves our unreserved admiration and respect. The Home Office and the Local Government Board act the part of a wise and economic head of the house to the nation, while each community has its own local board or authority to carry out hygienic provisions, to enforce sanitary principles, to prevent infection, to stamp out disease, to sweeten labour, and to prolong life.

I contemplated at one time submitting an historical summary of these features of sanitary legislation during the present generation, but not only would the task be very onerous, but it would be so lengthy that I should have very little time left to discuss the question set before me—"The Sanitary Aspects of Electric Lighting."

The propositions that I propose to submit and to demonstrate to you are these: 1. That electricity and light being analogous and identical forms of energy, the former is naturally the proper source of artificial illumination. 2. That all other sources of artificial illumination being dependent on the absorption of oxygen, and resulting in

* Lecture to Congress of the Sanitary Institute at Brighton, Aug. 26.

the vitiation of air, are injurious to health. 3. That the same authority which regulates the sanitation of our dwellings and the supply of our food, should also control the purity of the air we breathe, and of the light we work by.

Light, however it be produced artificially, is simply the equivalent of work that has been done elsewhere. Whether it be by the combustion of tallow or oil, by the burning of coal or of gas, by the glowing of a fine wire, or the formation of the brilliant arc, energy has been expended somewhere, to be transferred and reproduced in some other place in the form of light. The great principle of the conservation of energy teaches us that the amount of energy in the universe is a fixed quantity, that it can be neither created nor destroyed, that it can only be transferred, and that any expenditure of energy—work done—anywhere is the equivalent of energy utilised somewhere else. The rate at which this energy is expended is called power, and the amount of power which we foolishly call a horsepower, and which we roughly imagine to be equivalent to the power exerted by a horse in drawing a load along a road, is competent to produce an amount of light which is very simply measured. Our standard of light is the light given by a No. 6 sperm candle, burning 120 grains per hour. Now the energy of one horse-power constantly expended will give by the aid of

Tallow	the light of	6	candles.
Sperm	„	8·7	„
Oil	„	9	„
Gas	„	13	„
Electric current—glow	„	248	„
„ arc	„	1,492	„

The results to the air of these different modes of producing artificial illumination are well shown by the following table :

PRODUCTS OF COMBUSTION IN DEVELOPING 100 CANDLES PER HOUR.

Illuminant.	Quantity consumed.	Carbonic acid produced.	Water vapour.	Heat.
	lbs.	Cub. ft.	lbs.	Calories.
Tallow	2·2	51·2	2·3	9,700
Sperm	1·7	41·3	2·0	7,960
Oil	1·3	33·6	1·8	7,200
Gas	56 cub. ft.	40·3	2·5	12,150
Electricity	(Coal) 2·2lb.	0	0	257

Thus we see how very much more efficient electricity is than any other agent for the production of light.

The tendency of the teaching of the present day, is to show that the transmission of light waves and of electrical undulations is of the same character and at the same speed. Clerk Maxwell by theory, and Hertz by experiment, have placed this beyond doubt. A current of electricity passing through a fine filament first raises its temperature, and then as the current is increased in strength, it glows brighter and brighter until finally it is disintegrated and dissipated with great brilliance, and the light disappears. There has been no chemical consumption of material. The passage of the current has resulted in light, and light seems to have been the natural sequence of the flow of electricity. Energy has, however, been developed somewhere. There is a boiler for the production of steam, an engine for the application of power, a dynamo for the formation of electric current.

Gas has to be extracted from coal, purified in gas works, distributed through pipes, and chemically combined with the oxygen of the air in jets or burners.

The simple candle, however, is its own gas works. We simply apply a match and the flame itself becomes boiler, engine, and light emitter combined.

In all cases, therefore, we have to consider—(*a*) the source of energy, (*b*) the distribution of energy, (*c*) the utilisation of energy as light.

The sources of energy at our disposal are wind, water, coal (steam), gas, mineral oil.

The inconsistency of the wind in our climate renders it inapplicable for the steady and constant supply of power required for artificial illumination.

Water, on the other hand, is an unfailing source of power in some countries, but the quantity required to produce even small effects is opposed to its use anywhere but in mountainous or hilly districts where it is abundant. It requires a quarter of a ton of water falling one foot per second to produce 1 h.p., or falling 10ft. to produce 10 h.p. If we wish to maintain 10 ordinary electric glow lamps alight for five hours with a fall of 10ft., we should require 100 tons of water per hour, or 500 tons altogether.

At Keswick, in Cumberland, a central station has been established, which is worked by a fall of 20ft. of the water of the River Greta, generating 50 h.p. by means of a turbine. At Portrush, in Ireland, a fall of 26ft. generates currents that work a tramway to the Giant's Causeway. Many private houses in Scotland are so lighted.

There are innumerable places in the United Kingdom where this power is being allowed to run to waste. The non-utilisation is due probably to ignorance, and ignorance as much as indifference is the great obstruction which all new industries have to overcome, even when practicability and economy are almost self-evident.

The power of running streams and of the tides is used in some countries for grinding corn, but the power utilisable is small, and no practicable means have yet been introduced to employ them for small installations of electric lighting, though busy minds are actively engaged on this neglected field.

Steam, and therefore coal, becomes in all comparatively flat countries the principal source of power, while for small installations gas and mineral oil are extremely convenient, cleanly, and economical suppliers of energy. Indeed gas, as a source of heat, is coming more and more into use, and if a cheaper and coarser form of water-gas were distributed for fuel purposes, as it probably will in the future, it would solve the difficulty of the transit of coal, and prevent the possibility of that nuisance, the formation of smoke in the midst of shops and dwellings.

The power that is thus expended is employed in developing electrical energy. Motion is imparted to coils of copper wire in a field of magnetism, and a certain resistance has to be overcome when the lines of force in this field are cut by the wire; the energy of motion is absorbed, it takes the form of electricity, and as an electric current it can be transmitted to a distance, and there utilised. The amount of energy which is found in the form of currents is that delivered by the belt of the engine to the dynamo, less a small amount wasted in friction and in heat in the metal of the dynamo; but this is so small that it is a common thing now to obtain dynamos with an efficiency of 94 per cent.—that is, 6 per cent. only of the power applied to it is lost as heat in the dynamo itself.

If a child has a skipping rope made of copper wire and, with its face turned due north or south, it skipped, the rope would cut the lines of magnetic force of the earth in the proper direction, the rope would experience resistance, energy would be absorbed by the rope, and electric currents would be developed from hand to hand of the child. The child thus becomes an animated dynamo. The lines of force of the earth flowing north and south are cut twice in each revolution of the skipping rope, but alternately in opposite directions. Hence the currents generated are alternately flowing in opposite directions, and the child becomes an alternate-current dynamo. It is a very simple thing to straighten these currents, and to make them flow continuously in the same direction, and to convert these alternate effects into continuous currents flowing in the same direction.

Now, all electric currents require an E.M.F., or a difference of electric pressure to drive them through the resistance of metallic conductors, in the same way that water and gas require pressure to drive them through pipes. This E.M.F. in the case of the skipping rope is very minute, because the intensity of the earth's magnetic field is very small (it is only $\frac{1}{20000}$th of the field of an ordinary dynamo), the motion of the rope is comparatively slow, and there is only one cutting conductor. If we increase the number of conductors, their speed, and the strength of the field, we can magnify the electric pressure to any amount.

All new ideas require new names to indicate them, and if they are new quantities capable of measurement, they require new units to compare them with numerically. Dif-

ference of electric pressure is called voltage, and the unit of comparison is a *volt*. The skipping rope develops only a very small fraction, about $\frac{1}{1000}$th of a volt. There are now dynamos at Deptford which will generate 10,000 volts, and a flash of lightning is the result of perhaps millions of volts. The human frame is very sensitive to voltage, 50 volts is scarcely perceptible, 100 volts give a distinct though slight shock, 500 volts are painful, and 1,000 volts might probably under certain circumstances kill a man, 10,000 volts if effective through the whole frame would certainly destroy life. We have recently read of a deplorable attempt in the United States to utilise this power for the execution of criminals, an attempt surrounded with sickening horrors, the result of the ignorance that exists at present as to the effects of electricity on the human frame.

The unit of electric current by which measurements are made is called an ampere. If an ampere be circulated around a bar or ring of iron, it will magnetise it with a definite amount of magnetism dependent on its dimensions and quality.

If it be transmitted through a bath of nitrate of silver, it will deposit four grammes of silver per hour. If it be driven through a fine filament of carbonised cotton 6in. long, such as Edison and Swan use for their glow lamps, by an E.M.F. of 100 volts, it will develop a brilliant light of 32 c.p.

The actual energy conveyed by the current is measured by the product of the volts and amperes, and this measures the rate at which energy is being transmitted or expended. The unit of measurement is called the watt, which is a much more scientific and accurate unit of power than the absurd horse-power that has become so rooted among our engineers. A man in pumping expends about 50 watts; in rowing a race he expends about a 100; in running rapidly up-stairs he expends 500 watts for a few seconds; a horse drawing a load on a level road expends about 500 watts. The so-called horse-power is 746 watts. An ordinary arc lamp consumes 500 watts, and an electric tramcar going at seven miles an hour, on an average tramway, requires a mean power of about 3,000 watts.

Electrical energy is measured and paid for in 1,000 watts or in *kilowatts* delivered per hour. A kilowatt-hour is called the Board of Trade unit of electrical energy, and it is defined in all provisional orders confirmed by Act of Parliament, thus:

"The expression 'unit' shall mean the energy contained in a current of 1,000 amperes flowing under an electromotive force of one volt during one hour."

This Board of Trade unit has not yet received a name. I have proposed to call it a *Bot*, from the initial letters of the Board of Trade; but there is generally a very strong aversion to a new name, however much it may be wanted, and we have during the past few years had a plethora of new names in electrical science.

One Board of Trade unit will keep an ordinary 10-c.p. glow lamp alight for 30 hours, or it will keep 30 of such lamps alight for one hour. In Newcastle this energy costs 4½d., in Liverpool 6d., in London 7½d., and in most other places 8d. Taking the cost at 6d., a 10-c.p. glow lamp would cost one-fifth of a penny per hour, which is the cost of a 5ft. gas-burner at 3s. 4d. per 1,000 cubic feet. There is thus very little difference between the price of gas and that of electricity.

The output of a dynamo is measured in watts, and as the number of watts in ordinary dynamos is necessarily numerous, the kilowatt, or 1,000 watts, is the unit employed. Thus, a dynamo of 100 kilowatts develops energy equivalent to 134 h.p., and as for ordinary purposes the ratio of the power utilised as electric current to the power indicated in the cylinders of the engines may be taken at 80 per cent., it will follow that it will require 160 h.p. to drive such a dynamo at full load.

The relations between mechanical and electrical measurements are thus very simple and wonderfully accurate.

One hundred kilowatts, or 100,000 watts, deliver sufficient energy to illuminate 3,000 10-c.p. lamps, and one of the most difficult problems which the electrical engineer has to solve is to design the best and most economical method of distributing this energy over an extended area. If the distribution be confined to one big building, like the Pavilion in Brighton, or the Post Office in London, the solution is simple. If it be over a widely scattered district, like Croydon, Wimbledon, or the districts of the great vestries of London, the solution is complicated. Every district must be governed by its own conditions, and be controlled by its own environments.

There are several modes of distribution under high pressure or low pressure; by means of alternate currents or of continuous direct currents; by two wires or three wires or five wires. Then, again, the supply may be for light or motive power, for street lighting, or for private lighting. If it be by high pressure, say of over 300 volts, then, as such pressures cannot be admitted into our houses, there must be a reduction of this pressure to the safe and ordinary 100 or 50 volts by means of alternating transformers or of secondary batteries.

The ruling guide is, of course, economy. A certain number of kilowatts are generated in the central station at a price per hour that is easily obtained from the coal bills, the stores list, and the wages sheet. A certain proportion of this energy is delivered to the consumers, and paid for by them by meter or by contract. A certain proportion is lost, wasted as heat in the apparatus and conductors. What is the proportion between the energy paid for and that generated by the central station? What is, in fact, the efficiency of the system? It is difficult in the present tentative and youthful condition of the industry to obtain a true answer. Most central stations are in their pioneer condition. I have, however, examined the figures of certain well-known systems, from which I gather that we may estimate the following efficiencies as fairly practical:

		Efficiency.
Low pressure:		
	Continuous direct current...	90 per cent.
High pressure:		
	Alternate current	60 "
	Direct current battery	50 "

In fact, one company—the St. James's and Pall Mall—working on the low pressure system, have on the first half-year of 1890 secured a return of 94·3 per cent. on the energy delivered, while another company, working on the high-pressure battery system, secured only 29 per cent.

In January of this year, at the Kensington Court central station, working at low pressure, 25,893 bots were registered and paid for, as against 28,291 generated and distributed, representing an efficiency of 92 per cent. At Dacre-street, Westminster, also working at low pressure, in the quarter ending June 24th—the summer and lowest quarter—the efficiency was 84·4 per cent. At the House of Commons the efficiency has been 89·8 per cent.

A simple way of looking at the matter is to find out the coal consumed per bot paid for by the consumer. It comes out—

Low pressure	9lb.
High pressure	17lb.

It is worth noting that it would require 38lb. of coal distilled in the gas works to produce the same light by means of the ordinary fish-tail burner.

The misfortune is that the low-pressure system is applicable only to confined and restricted districts. It involves the use of such heavy conductors, that as the district increases in extent, the weight of copper required varies as the third power of the radius of the area served. While with the high-pressure system the weight of copper required diminishes with the pressure used.

If must, however, be recollected that the use of high pressure involves the use of very highly-insulated conductors, and therefore what is saved in copper may be expended in insulation. The question that decides the economic use of high or low pressure is the distance or length of mains and feeders, when the difference between 17lb. and 9lb. of coal (or a penny per bot) is swallowed up in interest on capital and waste of energy in the heavy conductors required by the low-pressure system.

The consequence is that while compact areas, covered by a radius of half a mile, are best served on the low-pressure system, those supplied beyond a radius of one mile can be served economically only on the high-pressure system; while the intermediate range is to be considered simply with reference to its own requirements and its own condi-

tions, such as the supply of water and of coal, the convenience of water and railway carriage, the value of land, the demand of residential districts and of manufacturing and business quarters. Each district must therefore be dealt with on its own merits.

In London at the present moment several different systems are being used or installed for very similar districts. Thus we have the alternate-current transformer system at Brompton, St. Martin's, St. Giles, and the various portions served by the London Electric Supply Association, the high-pressure battery system in Chelsea, the low-pressure system aided by secondary batteries to regulate pressure and to maintain the supply of energy during the small hours of the morning, or when breakdowns or cases of emergency arise, in Kensington, Westminster, St. James's, Notting Hill, and St. Pancras. The proper system to be used is therefore still in a tentative condition.

The great question that divides the merits of the high and low pressure is that of safety to person. Grossly exaggerated accounts of accidents in America have seriously prejudiced the public mind against the high-pressure system. If people only saw for themselves the conditions that surround the distribution of electricity in the United States they would not be surprised at the accidents that have happened, they would wonder at there being so few. Poles are frequently carried down the principal streets of the towns carrying open telegraph, telephone, fire signal, and electric light wires all together on the same support without any particular rules or regulations. A lineman who ascends a pole to attend to a telephone wire is very apt to touch suddenly an electric light conductor. He receives a shock, and is thrown down, perhaps, on the ground and killed, or, perhaps, among the other wires, where he may be probably burnt or otherwise injured.

Such things are impossible in England. Mains and conductors must by legislation be placed underground in all towns; but where they are for local reasons placed overground they are subjected to carefully prepared rules and regulations and to watchful and constant inspection. A high pressure conductor is certainly dangerous if it were handled, but it should never under any circumstances be so placed as to be in a position to be touched by anyone but the skilled technical men who have the charge of its maintenance. There is no case on record of anyone being hurt on a well-designed underground system.

The great hygienic advantage of the electric light when illumining our dwellings and our workshops is not that it purifies the air, but that it prevents the air from being vitiated by the introduction into it of the products of combustion, such as carbonic acid, carbonic oxide, sulphurous acid, etc.; it prevents the air from being weakened by the abstraction of oxygen, and it prevents it from having its temperature raised by undue radiation, and by throwing into it heated gases.

While legislation and the greatest possible stringent regulations have been drawn up to prevent the adulteration of food and the poisoning of water, scarcely any attention has been devoted to the prevention of the admission of noxious gases and poisonous vapours into the air of our habitations. Carbonic oxide is a poison of the deadliest character, and gas jets are freely used which deliver copious discharges of this dangerous gas into the atmosphere of our rooms. If we were consistent in our legislation we ought to forbid the use of any burner which thus poisons the air. A man at rest exhales ·00424 cubic feet of carbonic acid gas (CO_2) and ·1189 cubic feet of air per pound weight per hour, while a gas jet burning five cubic feet of coal gas exhales four cubic feet of CO_2. The maximum proportion of CO_2 to air consistent with health is six volumes in 10,000, 10 volumes affect the heart, and 30 volumes produce headaches. Rheumatism, bronchitis, and other ailments proceed from higher proportions. In fact, five cubic feet of gas requires 8,000 cubic feet of pure air per hour to maintain it healthy. The electric light requires no such provision.

That the electric light is a powerful element of health is evidenced by the fact that those who use it not only feel all the better for its introduction, but their appetite increases, and their sleep improves, and the visits of the doctor are reduced in frequency. Workpeople work all the better, and absences from illness are far less frequent. In the Savings Bank in Queen Victoria-street, London, where 1,200 persons were employed, the absences from illness were so far reduced, that the extra labour gained paid for the electric light. In Liverpool and many other places the same result has been observed.

The influence of artificial light on the eyes has a very important sanitary bearing. Why is it that there is so much short-sightedness in the present day? Is it due to our mode of producing light? Some assert that the injury to the eyes is due to the heat rays and not the light rays. If that be so the electric light must be much less injurious than any other. On the other hand, no one can have experimented with arc lamps without having had his retina painfully affected, which leads one to think that the ultra-violet rays have some influence. No one has, however, ever complained of the influence of a steady glow lamp upon the eyes, and it is possible to read and to write for many hours by such a light without experiencing the least fatigue.

The electric current is not altogether free from being a cause of fire, and though its use is by no means very general, still it is used sufficiently to make itself felt as an element of danger in this respect. The following table shows the number of fires in London which can be traced to the different methods of lighting:

	1887.	1888.	1889.	Total.
Lamps	245	205	257	707
Gas	188	197	209	594
Candles	142	113	136	391
Electricity	0	1	2	3

The progress of the electric light in our homes has been much more rapid in England than in any other country, but its employment for street-lighting, for shops and manufactories has been infinitely more rapid and extensive in the United States than with us. In America the growth has been enormous. There are now 250,000 arc lamps illuminating the public streets and shops, and 3,000,000 glow lamps in dwellings, stores, and workshops.

The following table shows the development of the Berlin central stations:

Station.	Effective horse-power.						
	1884	1885	1886	1887	1888	1889	When completed
Friederickstrasse...	300	300	300	300	300	300	300
Markgrafenstrasse	...	1,000	1,000	1,000	2,400	2,400	3,100
Mauerstrasse	...	...	500	1,250	1,250	2,950	4,950
Spaudauerstrasse	...	...	...	...	...	2,000	4,000
Schiffbauerdamm	...	...	...	...	...	1,000	6,000
Total	300	1,300	1,800	2,550	3,550	8,650	18,350
16-c.p. lamps, or equivalent.........	2,500	4,600	13,229	24,660	34,750	...	..
Kilometres of cable	...	8	10	15	25	75	...

The progress in England has been very much checked by inordinate speculation and by terrible failures in some of the earlier work done. There is something very captivating in the practical applications of electricity, and something romantic in its mystery. The neophyte has rushed into it with remarkable fervour, and the lessons of failure have in consequence been very severe. The users of the light have also been paying heavily for the education and experience of amateur tradesmen and inexperienced contractors, and have neglected to avail themselves of the professional services of the experienced electrical engineer. People who would not build houses without the architect, nor construct bridges without the engineer, nor make their wills without the lawyer, rush wildly into the use of electricity without any professional assistance, where, above all things, experience and knowledge are essential to prevent disaster and disappointment. Large installations have been completed without specifications to guide the contractor, and without inspection to see that the work has been properly done. The user has paid violently for his temerity, and fires and accidents have been the result. The heavy price

of wiring a rented house, and the expensive character of the fittings proposed, have deterred many from adopting the light, even when it is within their reach. Highly-insulated wire is, unfortunately, expensive. All cheap wires are nasty and dangerous. There is nothing that becomes the electric light better than simplicity, and its effect is frequently marred by elaborate brasswork. It possesses also most active and widespread opponents, both in oil and gas—opponents who have benefitted by its introduction, and who are not slow to profit by its advance. The improvements in gas and oil lamps are as marked as the advancements in electric light, and as means of artificial illumination alone—that is, as far as light-giving power is concerned—there is little choice between the three, but oil and gas cannot lose those elements of discomfort and ill-health which differentiate them from the cool and pure glow lamp.

A very important question arises for discussion. Legislation has slipped in to place the virtual control of the supply of electrical energy in the hands of the local authority of the district to be served. Is this supply to be the result of the capital of private enterprise, or is it to be effected by raising money on the security of the rates?

It is argued that the supply of electricity being a purely commercial undertaking, it should therefore be carried out by a limited liability company. The Acts of 1882 and 1888 do not encourage monopoly, but rather court competition, and competition attracts capital. Competition properly regulated and controlled secures economy in supply, and certainly enforces economy in working, while it encourages improvements, and induces perfection of apparatus and novelty in processes. These arguments are plausible, but are easily refuted by those who desire to uphold vested monopolies. Direct competition always means ultimately enhanced cost to the public, for the same public has to pay for double plant, and each competitor only gets half revenue.

The supply of light is in precisely the same category as the supply of water or the supply of gas, and the days have certainly passed when the public will tamely submit to the transference of their right to such vested interests as those of water or gas companies.

It is very easy to argue *pro* or *con* on each side. The local authority has to regard the security of traffic, the safety of person, the repression of crime, and the proper supervision of the promises of its ratepayers. It is the custodian of the public interests. It has to control the health, cleanliness, comfort, and beneficial sanitation of its habitable dwellings. It therefore must secure the best light, and if it can do this, and at the same time relieve the rates which are generally creeping up to dangerous dimensions, then its action would be wise and economical. But it would be entering into commercial rivalry with an active competitor—the gas companies; and its commercial control by such a shifting authority as a committee of a town council or of a local board, subject to the changes of political warfare, to the vagaries of press dictation, and to the fear of November elections, is a very doubtful proceeding. On the other hand, in many instances, such bodies have successfully dealt with the water question, the tramways, and even with the gas. In fact, one-third of the gas capital (21 millions) in this country is in the hands of 173 local authorities, and more than half a million of profits go to the reduction of rates.

Bradford has already grappled with the question. It has established a central station for the supply of the electric light. Brighton, St. Pancras, and Bristol are doing the same, and many other places are following suit. They are shying at the probability of handing over their districts to a speculative company, with a virtual though not a legal monopoly, to supply electrical energy for 42 years. Many corporations contemplate a middle course. They have obtained the power for themselves, but they have farmed for shorter terms the right of supply to private enterprise, which can do what they are afraid to do—viz., speculate and experiment. The Board of Trade has sanctioned and facilitated such a transfer of statutory rights.

It is surprising that gas administrations in England have not been more enterprising in developing electric lighting. In Vienna, Rome, and Stockholm the gas companies have established central stations, and the progress of the industry in those cities is very great. The proper function of gas is to supply heat, not light, and as a source of power it has a future more brilliant than its past. If it could be supplied as fuel it would remove the troubles of coal transit and storage, of ash and dust removal, of smoke and of stoking. It has even been shown that it is cheaper to convert coal into gas on the spot, and to use the gas as the source of power, than to apply the coal direct for the production of steam in boilers. The waste of energy in the use of coal is enormous. The energy contained in 1lb. of coal if burnt in one hour is theoretically sufficient to supply 5·6 h.p. for that hour. The best practical result yet obtained by the steam-engine is scarcely 1 h.p.

The electric light is unquestionably the light of the future. Its use is advancing with leaps and bounds. Not only is it naturally the proper source of light, but economically it must eventually supplant its rivals. When electrical energy is generally distributed through our towns, and its supply is continuous and properly controlled so that it is always within the reach of all, and when means can be devised to wire up houses as cheaply as they are now fitted for gas, everyone will take it, not alone for its beauty, but because it is, above all, a source of health and comfort.

ON SOME EXPERIMENTS IN RADIOMETRY.*

BY A. R. BENNETT, MEMBER.

(Concluded from page 134.)

Although rotation occurs best in screens having an opening to the outer air, it will take place when no such opening occurs, as in Fig. 12. Thus, a vane inside a metal cylinder will oscillate, and then rotate when heat is applied to the exterior of the cylinder. With thin metal the application of the finger to the metal is sufficient to impart motion.

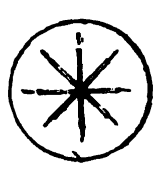


Fig. 12.

These motions are probably due to the same cause as that of the unscreened fan, Fig. 6. The screen radiates the heat it receives from the impinging ray; the air next the screen is warmed and made to ascend, and is replaced by colder air advancing on all horizontal planes. The course of the currents is determined by the form of the recess enclosed by the screen; when the form is circular, or snail-like, a well-defined whirl or eddy is established, and so continuous rotation is imparted to the vane or cap. The movements caused by a screen heated before being placed round a vane, or subsequently heated at one or more points by the application of a poker to its exterior, probably have a similar origin. That the currents causing motion are horizontal seems proved by the fact that the fans of the vanes used were strictly vertical, and therefore not adapted for indicating ascending currents; and the light tissue caps supported on fine needle-points would be apt to be lifted off their supports and overturned by ascending currents, whereas they rotate horizontally for hours together. Yet that ascending air plays an essential part in the phenomenon is proved by the fact that covering the top of a screen stops the motion.

A hot vane placed within a cold screen will rotate until it cools; so the condition necessary to secure rotation appears to be a difference of temperature between the air and the screen or vane.

Screens of various kinds were tried—of high absorptive power, like white paper and paper faced with lampblack; and of high reflective power, like bright tinned iron. All answer well, but the tinned iron best. With a bright snail-like screen, the difficulty is not to get the vane to rotate,

* Paper read at the special meeting of the Institution of Electrical Engineers at the Edinburgh International Exhibition, July 17, 1890.

but to stand still. Notwithstanding the vigorous motion of the vanes, exploration of the interior of the screens by suspended silk fibres does not reveal the existence of such powerful currents as might be expected.

A vane at rest will be disturbed by a new object such as a book being placed near it, however gently the act may be performed in order to avoid creation of an actual draught. It will, after some seconds of oscillation, and perhaps a few complete turns, adjust matters with its new neighbour and again become quiet. The placing of a similar book on the other side will renew the motion, which always follows the withdrawal or addition of an object. With a sensitive vane alternate deflections to the right and left may be brought about by the shifting of books.

A comparison between these results and those obtained with the radiometer is inevitable. With modifications consequent on the attenuation of the air in the latter instrument, the action in both, tending to the establishment of currents of defined direction, is probably identical.

The discharge from an influence machine directed across the openings in the screens will cause rotation of vanes or caps within them, as will the establishment of draught however created.

For the instrument consisting of a vane, cap, or sphere, within a screen, the author proposes the name of radioscope.

After experimenting with vanes and caps it was determined to try spheres.

Some indiarubber balloons were distended and hung by fine silk threads, such as are used for suspending the needles of astatic galvanometers.

All the effects produced by the vanes and caps were observed, modified by the winding up of the thread consequent on rotation, and some curious ones in addition.

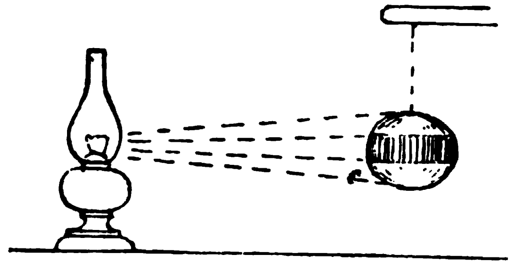


FIG. 13.

A balloon was found to invariably turn one particular face to the observer on being approached, and this face it would keep toward him wherever he moved, so that he could cause it to rotate by walking slowly round it. A lamp, kettle, or other source of heat, carried round had the same effect. Observation showed that indiarubber balloons are never truly spherical when distended, and that one side is always a little lighter than the other; and that it was the light side that always turned to the heat. The effect may be accentuated by gumming a piece of paper, or foil, on one side, so making it heavier. No effort on the part of the observer can induce the paper or foil to face him. Wherever he goes it immediately retreats as far from him as it can.

If a fairly spherical balloon is surrounded by a zone of paper, hung on a fine fibre and allowed to attain a state of rest, it will, when subjected to heat, begin to swing to and fro towards and from the heat, and then to rotate slowly, Fig. 13. This effect is increased if the zone of paper is wetted, or one of wet linen used.

Generally, a few seconds after turning on the heat, rotation begins, continues for a few seconds only, ceases, and then reverses. The rotation in the second direction is much better sustained, and will continue until the force acting is counterbalanced by the winding up of the fibre.

It being evident that evaporation exercised a powerful influence on the action, and the manipulation of wet paper belts being inconvenient, about half an ounce of water was put into a balloon before it was blown out, and this yielded a very convenient and, at the same time, fairly sensitive instrument.

After shaking the water about so as to well wet the interior of the balloon, it was hung on a single silk fibre and left in the dark to come to rest, which, having done, a lamp was caused to shine on it from a distance of 3ft. After swinging a bit it turned some half a revolution to the left, stopped, and then began to rotate to the right, that is to say, in the reverse direction to the hands of a watch. After a few complete turns it paused, then continued for several turns more, sometimes pausing and going on without a reversal, sometimes reversing a little, and then continuing. When it finally stopped, the lamp was withdrawn a couple of feet, and renewed rotation was the result. Another stoppage soon occurred. The lamp was then withdrawn altogether, and rotation recommenced and continued for several more turns. The experiment was repeated many times with slightly varying but substantially the same results. The best results were, however, attained with balloons belted with foil, and by keeping the lamp 3ft. off. When closer, rotation was not so long continued.

Suspending the balloon in a packing-case so that it is surrounded on three sides by wood, increases the uniformity of the results, although they occur markedly when suspended unscreened in a room.

The rotation produced appears to the author to be identical with that of the vanes and caps. Although the particles of bodies and gases, air included, expand when heated, indicating repulsion, yet heated bodies have a tendency to motion towards each other through the rarefaction of the air between them and the presence of the heavier air behind, and motion will occur if the friction or other restraining forces are not too great. A heated body has similarly a tendency to move towards any other between which and itself its radiation rarefies the air. In the case under consideration a cone of heat from the lamp falls on the balloon, and is radiated, rarefying the air between them, and causing the balloon to slightly approach the lamp. The perpetual endeavour which follows to adjust between this horizontal force and the vertical one due to gravity may cause the balloon to rotate, although air currents due to heat radiated from the balloon probably help. A difference of temperature between the different parts of the balloon is obviously necessary. All the results point to this—stoppage and reversal after the lamp has been shining some time, and subsequent continuance. The stops and reversals give the balloon time to cool by radiating to the walls of the packing-case and other surrounding objects. When equally heated all round there is no tendency to deflection and no rotation.

The resumption of motion after the withdrawal of the lamp may perhaps be explained in the same way, the heated balloon now replacing the lamp as the source of heat and acting with the walls of the room or of the packing-case. When cooled by radiation to the same temperature as surrounding objects it comes to rest.

The correspondence between the effects produced by the charging up of the vane of the radiometer and its subsequent discharge, and the heating up and subsequent cooling of the balloon, is noteworthy. In each case motion is produced by the charging process until the limit of capacity is reached, and after a dead period corresponding to the full condition is resumed during the discharge or cooling.

This class of experiment to ensure success requires the observance of stringent conditions. The room should be dark, its fireplace closed, and every other precaution taken to exclude draught. At most two observers should be present, and they should keep as far from the balloon as possible and remain still. The suspending fibre should be single, as deceptive rotation may be got by the untwisting of a double thread, and the balloon must be hung up and left in the dark to come to rest before having the heat turned upon it. The lamp used should be the sole illuminant in the room. For these reasons I have not attempted to reproduce the experiments in a hall like this. A balloon as truly round as possible should be used; a flat side will not pass the lamp, but oscillate alternately to the left and right before it.

The direction of rotation appears capricious, although extremely well marked, and persistent when once started. Possibly it is determined by the suspending fibre retaining some directive force, but the matter has yet to be properly investigated.

By far the greater number of experiments gave rotation in the reverse direction to the motion of the hands of a watch. Sunlight, suffered to fall on the balloon through an opening, may be substituted for the lamp. A kettle of hot water, or even the close approach of the hand or the body to a ballon suspended by a single cocoon fibre, will start rotation. Between each experiment the balloon should be lifted off and the fibre allowed to untwist. The violence with which it does this after prolonged rotation shows that the work done by the force, whatever it may be, is by no means inconsiderable.

The resemblance the rotation of a balloon under the influence of heat applied to part of its circumference to that of the earth is certainly striking, although it may seem far-fetched to compare the world with an inflated windbag. Like the balloon, the earth receives heat on one side, and radiates it on the other, and evaporation, when the wet zone is used, combined with expansion of air, occurs in both uses. It is true the balloon has its atmosphere inside its shell, but the shell is elastic and capable of distortion in the direction of the heat, a distortion which may possibly have something to do with the motion.

The author regrets that, owing to the putting forward of the date of the meeting of the Institution in Edinburgh by a couple of months, the experiments are not so complete, nor the explanations so exhaustive and satisfactory as he should have liked them to have been.

APPENDIX.

Notes on Rotation of Spheres.

Indiarubber balloon	simply distended.	Will deflect and oscillate, but not rotate.
Do. do.	covered with film of water.	Will rotate until film has evaporated.
Do. do.	with zone of dry paper.	Will rotate slowly and intermittently.
Do. do.	with zone of lamp-blacked paper.	Will rotate slowly and intermittently; motion excessively slow.
Do. do.	with zone of wet paper or wet linen.	Rotation much quicker, freer, and longer sustained. Many trials gave average speed as one turn in 1·25 minutes. Between the two stages of heating and cooling, motion in the same direction will continue for an hour.
Do. do.	with ½oz. of water inside.	Rotation not so free as foregoing, but arrangement more convenient.
Do. do.	with zone of tin-foil.	This gave the best results. In some cases rotation in the same direction continued between heating and cooling for over three hours, the number of turns being from 150 to 160.

With some of the arrangements, notably the wet paper zone, a lamp is unnecessary. If the balloon is suspended breast high the careful approach of the body, so as not quite to touch, will induce rotation. Balloons of French make, which may be purchased at most indiarubber shops, are best, as they are lighter and far more symmetrical than English or American.

ELECTRICITY FOR TRAMWAYS.

REPORT BY THE CHAIRMAN OF THE WIGAN TRAMWAYS COMPANY.

Mr. Councillor Richard Johnson, chairman of the Wigan Tramway Company, recently visited the electrical works in connection with the North Metropolitan Tramways Company, Canning Town, with the object of ascertaining the prospects of introducing electricity as a tram motor in Wigan, and has presented the following report to his co-directors:

Gentlemen,—In accordance with your instructions I visited and inspected the electrical works in connection with the North Metropolitan Tramway at Canning Town, and the following observations are the result thereof.

The methods adopted for the practical solution of electrical traction depend either on supplying all the trams, by means of the rails, with electricity from one central station, or supplying each individual tram with the means of producing its own current of electricity.

At the works at Canning Town the latter method is adopted (with what financial success I know not), and each tram is supplied with accumulators or sets of storage batteries, which are fully charged before starting, and generate a current of electricity which works a motor connected by gearing with the driving wheels of the tram.

Various types of accumulators appear to have been tried, and the one that is the most economical consists of a series of leaden grids coated with some composition, generally red lead, and immersed in diluted sulphuric acid. Such a combination requires to be charged, or, to speak in homely language, wound up like a clock.

To accomplish this it is necessary to have a room or station, which they have at Canning Town, much the same size as the depot at the Pemberton section of the Wigan Tramways. This station is divided into two parts, one being used for the engine and dynamo, and the other for the purpose of changing the accumulators that have worked down.

For this purpose long benches run down each side of the metals, and they are constructed in such a manner that it is comparatively easy to remove the exhausted accumulators and replace them with others freshly charged.

When charged the accumulators are placed in the base of the car to supply the motor with the current.

As far as I could learn, the car will run about half a day with 12 accumulators, six on each side, and it is absolutely necessary the car should be of special construction on account of the weight of the accumulators, which is from four to six tons.

When the car begins to work, the accumulators gradually give back a portion of the charge they have received, and, in fact, run down like a clock until they exhaust themselves.

My opinion is that this system will not do, especially in a district like ours, subject to mining subsidences, and it is fraught with difficulties in other districts—namely, great expense in keeping the accumulators in order and properly charged.

There is an enormous loss of efficiency when comparing the mechanical work done by the initial source of power—namely, the engine used to drive the dynamo and the amount of work done by the motor.

There are also other losses which are due to causes that cannot easily be corrected; for instance, leakage, which is certain to be serious when dealing with sulphuric acid, the splashing of the sulphuric acid on the sides of the batteries, owing to the shaking of the car, causing corrosion of the connections, and thus cutting off part of the current.

The jolting of the car is also very apt to displace the leaden grids, and cause the pieces of composition to fall between the plates, thus neutralising the current by "shorting" it.

The efficiency of the accumulators may thus be easily destroyed, and it would be valuable information could we get at the depreciation written off by the company working the North Metropolitan. The engineer, in answer to a question, said it was difficult to get at depreciation on account of the excessive mechanical power they used for driving the dynamo, but this need not affect depreciation from other causes.

Another objection which appears to me to be fatal to this system is that it is difficult to regulate the current given off by the accumulator to accommodate the different loads we in Wigan are called upon to carry.

This is important, as the life of an accumulator must depend greatly on the current being drawn regularly from it, and this is almost impossible with different loads and varying gradients.

Another objection I have is that the accumulators give off unhealthy gases, principally hydrogen; in fact, the bad smell inside the car at Canning Town put me on the scent of the sulphuric acid.

I do not see how regularity of work can be secured, as the accumulator must generate most power when fully charged, and not like a clock, where the power is fully maintained until quite run down.

To summarise my objections:

(1.) Accumulators only give off a portion of the power put into them.

(2.) They only work well when at rest, and cannot stand the jolting inseparable from any but fancy tramways.

(3.) They require skilled labour to charge and work them.

(4.) They cannot be relied on unless the strain is regular, which is impossible.

The engineer of the electric company displayed every anxiety to supply all information to the deputation except as to depreciation, and on this matter he had not much to say.

Richard Johnson,
Chairman of the Wigan Tramways Company, Limited.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the week ended August 22 amounted to £5,121.

Western and Brazilian Telegraph Company, Limited.—The receipts for the week ended August 22, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,994.

NEW COMPANIES REGISTERED.

Vaughan-Sherrin Electrical Engineering Company, Limited. Registered by Lowles and Co., 26, Martin's-lane, E.C., with a capital of £25,000, in 4,975 ordinary shares of £5 each, and 25 founders' shares of £5 each. Object: to carry into effect an agreement, made Aug. 11, between John Vaughan-Sherrin of the one part, and Richard Frederick Dempster, on behalf of the Company, of the other part, and to manufacture electric motors, generators, tricycles, Bath chairs, boats, and machines, or any carriage, vessel, or machine, either wholly or partly propelled or worked by electricity, upon any system whatever, and for carrying on the business of electrical and mechanical engineers, and all manufactures connected therewith or relating thereto. The first subscribers are:

	Shares.
E. H. Roberts, 85, Rushmore-road, Clapton, N.E.	1
H. E. Woodgate, 123, Pall-mall	1
H. Snarrin, 19, Duncan-terrace, N.	1
H. H. Paice, 81, Sydner-road, N.	1
J. H. Dempster, 59, Abbey-street, Bermondsey	1
T. J. Edwards, 18, Standard-street, Newington, S.E....	1
E. M. Simmonds, 17, Duncan-terrace, N.	1

Mr. John Vaughan-Sherrin is appointed managing director at a salary of £300 per annum. The regulations contained in Table A, with slight modifications, apply.

PROVISIONAL PATENTS, 1890.

AUGUST 18.

12914. **Improvements in switches for controlling and regulating double or compound electric motors, especially applicable to traction or marine propulsion.** Alfred James Jarman, 11, Furnival-street, Holborn, London.

12915. **Improvements in brush holders for dynamo-electric motors and generators.** Alfred James Jarman, 11, Furnival-street, Holborn, London.

12952. **Improvements in arc lamps.** William Lowrie, Charles James Hall and Huibert Doyer, 433, Strand, London.

12957. **Improvements in electric lighting by means of coin freed apparatus.** Dixon Henry Davies and John Mesney Tourtel, 28, Southampton-buildings, London.

12958. **Improvements in apparatus for effecting, by insertion of a coin, the production of electric light for a certain time.** Dixon Henry Davies and John Mesney Tourtel, 28, Southampton-buildings, London.

AUGUST 19.

12979. **Improvements in thermo-electric generators.** Harry Barringer Cox, 46, Lincoln's-inn-fields, London. (Complete specification.)

12997. **An improved electrical rock-drill, coal-digger, or earth-cutter.** William Blanch Brain, Arthur J. Arnot, and Frank Baker, 321, High Holborn, London. (Complete specification.)

13002. **Improvements relating to induction coils or transformers chiefly designed for use in welding or otherwise working metal by electricity.** Henry Harris Lake, 45, Southampton-buildings, London. (Elihu Thomson, United States.) (Complete specification.)

13003. **Improvements in the manufacture of electrodes for primary and secondary batteries.** David Pepper, jun., 45, Southampton-buildings, London. (Complete specification.)

13006. **Improvements in welding or otherwise working metals by electricity, and in apparatus therefor.** Henry Harris Lake, 45, Southampton-buildings, London. (Elihu Thomson, United States.) (Complete specification.)

13009. **Improvements in printing telegraphs.** John Byron Odell, 45, Southampton-buildings, London. (Complete specification.)

13013. **Improvements in the manufacture of electrodes for primary and secondary batteries.** David Pepper, jun., 45, Southampton-buildings, London. (Complete specification.)

13024. **Method of, and apparatus for producing by means of electrolysis decomposed products of melted haloid salts, and other combinations of metals.** Gustaf Otto Rennerfelt, 77, Chancery-lane, London. (Complete specification.)

13042. **Improvements in or appertaining to electric railway systems.** Charles Joseph Van Depoele, 6, Lord-street, Liverpool. (Complete specification.)

13044. **A new or improved method and apparatus for effecting economy of electric force in electric writing.** Paul Etienne Bardonnaut and Pierre Juppont, 6, Lord-street, Liverpool. (Date applied for under Patents Act, 1883, Section 103, 20th February, 1890, being date of application in France.) (Complete specification.)

13049. **Improvements in electric telegraphs, in part applicable for signalling on racecourses and elsewhere.** Francis Edward Macmahon, 24, Southampton-buildings, London.

AUGUST 20.

13107. **Improvements in electric arc lamps.** Karl Kurmayer, Sigmund Cappilleri, Hermann Grunwald, and Carl Holzapfel, 45, Southampton-buildings, London.

AUGUST 21.

13123. **Improvements in electricity meters for alternating or interrupted currents.** George Hookham, 7, New Bartholomew-street, Birmingham.

13129. **Improvements in safety fuses or cut-outs for electrical circuits.** Arthur William Slater, 10, Lansdowne-place, Blackheath.

13147. **Improved electrical drilling machine.** William Henry Willatt, 28, Witham, Hull.

13171. **Improvements in fittings for incandescent electric lamps.** Leopold Hoepl and Emile Courtin, 4, South-street, Finsbury, London.

13175. **Improvements in miners' electric safety lamps.** William Peto, 8, Quality-court, London.

13187. **Improvements in electro-motors.** Ross Franklin Moore, 24, Southampton-buildings, London. (Complete specification.)

AUGUST 22.

13190. **Improvements in exciting electromagnets and electromagnetic machinery.** Rankin Kennedy, 10, India-street, Kilmarnock. (Complete specification.)

13199. **Improvements in electric telephone switch apparatus.** John Graham, 46, Belmont-street, Haverstock Hill, London.

13212. **Improvements in electric accumulators.** Robert Drysdale, 7, Cherry-street, Birmingham.

13233. **Improvements in portable electric lamps, more especially intended for miners' use.** The Mining and General Electric Lamp Company, Limited, and William Moscrop, 47, Lincoln's-inn-fields, London. (Complete specification.)

13239. **A method of and appliances for producing magneto inductions.** Louis Bollmann, 28, Southampton-buildings, London.

13256. **Improvements in coin-freed electrical apparatus.** John Thomas Gent, Alwyn Walter Staveley, and Isaac Hardy Parsons, 4, South-street, Finsbury, London.

13260. **Improved means for the distribution of electricity.** Michael von Dolivo-Dobrowolsky and Paul Mamroth, trading as Allgemeine Electricitäts Gesellschaft, 47, Lincoln's-inn-fields, London.

AUGUST 23.

13261. **Improvements in and connected with primary galvanic batteries.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

13276. **Improvements in covering wires to protect them from corrosion, especially applicable to electrical conductors.** Edward Shinn, 26, Castle-street, Liverpool.

SPECIFICATIONS PUBLISHED.

1889.

12236. **Alternating, etc., electric currents.** Swinburne. 8d.

12237. **Electric transformers.** Swinburne. 8d.

12503. **Dynamo-electric machines.** Andersen. 8d.

14971. **Secondary batteries.** Dujardin. 6d.

1890.

7988. **Welding metals electrically.** Coffin. 6d.

7989. **Welding metals by electricity.** Coffin. 6d.

7990. **Electric welding.** Coffin. 6d.

7991. **Electric welding.** Coffin. 6d.

7992. **Electric welding.** Coffin. 6d.

7993. **Welding metals electrically.** Coffin. 6d.

7994. **Welding metals electrically.** Coffin. 8d.

10134. **Electric cables, etc.** Johnson (Cheever). 4d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	1¼
India Rubber, Gutta Percha & Telegraph Co. ...	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	8

NOTES.

Austrian Technical College.—A technical school of electricity, under Government control, is to be opened in Vienna in October.

Strike of Westinghouse Men.—About 1,800 men employed by the Westinghouse Electric and Machine Companies at Pittsburg, U.S., have struck for a nine hours' day.

Newcastle Public Library.—At a meeting of the Newcastle Free Library Committee it was decided to recommend the Council to fit up the library with the electric light.

Statue to Gay-Lussac.—The statue of Gay-Lussac, executed by Millet, was unveiled at Limoges, on Aug. 11th, by the Minister of Commerce and the Association Scientifique of France.

Manchester Town Hall.—The Town Hall Committee of the Manchester Town Council are considering the advisability of the introduction of an installation for electric lighting.

Dr. Hertz.—It is not generally known that Dr. Hertz, whose researches into electrical wave-lengths have already made him famous the world over, is, as Dr. Louis Duncan recently says in his paper on the subject, a young German, yet scarcely 30 years old.

Chelmsford.—The Chelmsford Jubilee clock is to be lighted with two 32 c.p. incandescent lamps by Messrs. Crompton at a cost of fixing of £3 and annual charge of £4. 13s. 8d. instead of £12, which is the present cost of lighting the clock by gas.

Gas-Tight Switches.—Electric switches are now made in watertight and gas-tight cases, provided with stuffing-boxes, to allow proper movement of the handles for use in situations where damp air or acid fumes would tend to deteriorate the connections.

Horse Fair by Electric Light.—The first instance of its kind took place a week or two ago at New York, where a very successful horse fair was held under electric light, and all the points of the horses were as distinctly brought out as if they were in the sun.

Hastings.—It is thought by the ratepayers of Hastings that the electric lighting project could not be carried out for the amount estimated by the borough surveyor (£5,550, with 5 per cent. for contingencies), and it was decided to ask the Mayor to call a public meeting on the subject.

Sheerness.—The Sheerness Local Board of Health have under consideration the question of adopting the electric light in the place of gas for street lighting purposes. They have given their surveyor instructions to provide them with full information on the subject at their next meeting.

Maxim-Weston Stock.—The machinery, plant, and stock of the Maxim-Weston Company, now in liquidation, is offered for purchase by tender in one lot at the company's works, Kingsland Green, Dalston. The particulars may be obtained of the liquidator, at 55, Victoria-masions, Westminster.

Fulham Guardian Board.—The clerk reported that Messrs. Woodhouse and Rawson had sent in a tender for the electric lighting work at a cost of £3,190, guaranteeing the same for 12 months. The clerk explained that the tender had not been solicited, but it was a very low one. It was referred to committee.

Electric Mining Plant.—One of the first electric mining plants erected in West Virginia has just been put up by the Thurmond Coal Company at its mines at Fayette. The plant will cost over 20,000dols., and will consist of lights as well as mining machinery. The dynamos will be of 350 amperes capacity.

Glasgow Railway Station.—The electric lighting of the Caledonian Railway Station, Glasgow, when extended, will be the largest single installation out of London in the United Kingdom. There will be 1,700 incandescent lamps. Two new engines are to be put down, and the installation is to be ready in three months.

Music by Telephone.—An experiment made on Wednesday, in Berlin, in transmitting operatic music by telephone from the Opera House to the Urania Theatre of Science was a complete success. It is hoped that it will be possible to make an arrangement with the telephone exchanges to furnish other places with music through the telephone.

Weybridge.—The consent has been given by the Chertsey Sanitary Authority for the granting of a provisional order for Weybridge to the Laing, Wharton, and Down Syndicate. Partial electric lighting of the district has already been carried out by this company for some time by overhead wires, and one of the conditions of assent is that all wires shall be removed and laid underground within two years from the date of the order.

Huddersfield.—It was reported at the last monthly meeting of the Huddersfield Town Council that the sub-committee had considered the advisability of taking steps for the establishment of an electric light station under the provisional order which the Corporation has now obtained, and a deputation, consisting of the Mayor, together with members of the sub-committee, were appointed to inspect the electric light systems at work in other towns and to report thereon.

Ship Lighting.—The contract for lighting the four new steamers for the Manchester, Sheffield, and Lincolnshire Railway Company has been given to Messrs. Paterson and Cooper. Two of these are being built by Earle's Shipbuilding Co., Hull, and two by Swan and Hunter, Newcastle. Messrs. Paterson and Cooper have on hand besides the above the lighting of the s.s. "Innamincka," "Garnet," "Tuokar," "Arranmore," "City of Dundee," and H.M. training ship "Empress."

Electric Drills in Government Dockyards.—Electric drills are in successful use at the U.S. Government Navy Yard at Brooklyn. The box containing the drill is about 18in. long, and contains only the motor and a coil of wire for connections. The motor runs at a speed of 2,800 revolutions per minute, but is geared down so that the speed of the drill is comparatively low. An inch hole can be bored through a half-inch iron plate in 30 seconds with one of these portable machines.

A Corner in Carbons.—According to press dispatches, the Thomson-Houston Company has purchased the National Carbon Company at Cleveland, and are negotiating for the Standard Carbon Company of the same city. The Brush factory is already controlled by them. This leaves only the Globe Company competitors. The works mentioned

with another at Fremont, owned by the Thomson-Houston, together turned out 70 per cent. of the total 90,000,000 carbons annually used in the United States.

Electric Railway between Elberfeld and Barmen.—A contract has just been entered into by Messrs. Siemens and Halske, of Berlin, with the towns of Elberfeld and Barmen (Westphalia), to construct and maintain at their own expense an elevated electric railway between both places for the purpose of carrying passengers and goods. The two towns are entitled to acquire the property of the railway for a fixed sum after a five years' period of successful running. It is intended to begin work in the early spring of 1891, and to open the railway early in 1893.

Arc Light Prices.—The tender of the Thomson-Houston Company for arc lighting at Napa, California, has been accepted at the following prices: 24 arc lights, 1,200 c.p., until 1 a.m., 10 dols. (£2) each; 24 arc lights, 1,200 c.p., all night, 15dols. (£3) each. At Springfield, Ohio, the Common Council has recently let the contract for 100 arc lights of 2,000 c.p. to the Thomson-Houston Company at 100dols. (say £20) each per annum; lights to shine from half an hour after sunset to one hour before sunrise every night in the year, with deductions for lost time *pro rata.* We suppose the first case are monthly rates, though it is not so stated.

Lithanode Lamps.—We see that considerable attention is being given in the French and Belgian papers at the present time to a new lamp (there called the "Stella") lately presented to the Academie des Sciences. This is the lithanode battery invented by Mr. Fitzgerald, the property of the Mining and General Electric Lamp Co. Trials have been made in Belgian mines, apparently with considerable success. The company are understood to guarantee the lamp for four years; its weight is given as 1,800 grammes, and it will burn for 16 consecutive hours. The mines of Anzin are reported as having just made a very large application of this lamp.

Iridium Filaments.—The following particulars are given without further comment by the *Scientific American* under the title of "The Iridium Light": Upon a suitable plate or support, such as wax, the form of the desired filament is pencilled with plumbago; this is placed in an electrical iridium bath. When a film of sufficient thickness is deposited upon the stencilled design, the filament is peeled off from the beeswax and the plumbago brushed off the back. Iron wires are used as conductors. The filament is incandesced in the atmosphere, as it is practically non-combustible, or, for security against breakage, it may be incandesced in any suitable gas or in a vacuum.

Electric Slaughtering.—Two inventors of Gunnison, Colorado, have brought out an electric slaughtering apparatus for animals. It is stated that meat killed this way will keep longer, and that pork is found to be entirely free from trichinæ. The apparatus consists of a pen with a metallic floor in two sections connected to a high-pressure dynamo, and the animal is first driven through a pool of water to damp its hoofs. Direct application of electrodes can be effected if desired. The proposers of this method appear to have tried it in practice, and if they find it successful in all respects they may be expected to press its use upon the attention of the large slaughtering firms of Chicago and elsewhere.

Switzerland.—A central electric station has recently been opened at Locle, in Switzerland, and is a further example of the utilisation of waterfalls for the generation of electricity, now very general in that country. The town of Locle is situated in a deep valley, the waters of which fall into an artificial lake. From here iron tubes conduct the water to the station, where the turbines are directly coupled to Thury dynamos. The current is distributed at 180 volts within a radius of about two miles by the three-wire system. There are at present 185 public lamps and 1,500 lamps in private houses, besides motors for various purposes. The total motive power used for business purposes already amounts to 50 h.p.

Trouve Electric Safety Lamp.—The portable safety lamp, devised by M. Gustave Trouvé, with a primary battery of surcharged bichromate of potash, is now employed in the French Government powder magazines at Servan-Livry and at Ripault, as well as in the military artillery schools, the Paris Gas Company, and the fire brigade at Paris, and the Italian navy. The current furnished by this lamp is 1·5 amperes at 11·4 volts, or 17·10 watts during three hours, or a total of 51·3 watt-hours. This corresponds to a light of 4·2 c.p. for three hours or of 1 c.p. for 12 or 13 hours, which is found considerably superior to that of the usual type of miner's lamp. The weight of the lamp and cost of maintenance are not given.

Electric Ship-Signalling in Fogs.—An ingenious invention was recently described in *Engineering* for distinguishing and safeguarding vessels in fogs. It is based on the fact that when a fog hovers over water there is always a clear space of a few feet between the surface of the water and the bottom layer of the fog. Each vessel is to be provided on one side of its bow, just above its highest water-line, with a horizontal row of glazed portholes, and on the opposite side with a vertical row of like holes. Electric lights are arranged to throw beams of light forward and laterally through these portholes, the different arrangement of which is to serve to show the course of the vessel. Sighting portholes, carrying telescopes, are also to be provided close to the former porthole.

Mitcham.—We should imagine, when so much fight is being made over lighting contracts, that it would be worth while giving a little attention to Mitcham. At the Vestry meeting held last week the lighting question was raised and discussed. They have 268 lamps, and previously the place has only been lighted for 10 months from sunset to one o'clock, for which they have been paying £3 per lamp per year. Now it is proposed to keep them alight all night for the cost of £3. 15s. each. Six lamps are to be added, the lamps are in bad condition and must be repaired, zinc plates are to be put on, and with other charges a grand total of £1,150 per year is proposed to be raised by the Vestry for public lighting. There seems to be a very fair chance for electricity under such conditions.

Woolwich.—A special meeting of the Woolwich Local Board has been held to consider the notice of motion by Mr. Green to rescind the resolution of the last meeting giving their consent to a provisional order granted to the Woolwich District Electric Light Company to supply electricity for lighting purposes in the parish of Woolwich. Mr. T. Hughes seconded. The Rev. J. W. Horsley said that the electric light was much healthier than poisonous gas in churches, houses, and shops. He wished the electric light movement God-speed. The chairman said that the promoters of the company were himself, Messrs. Dale, Campbell, Randall, R. Webb, Whale, Mellish, and Price. After some discussion, the question of rescinding the resolution was postponed till the next meeting in order that the

subject may be discussed by a committee of the whole Board.

Chelsea Electric Station.—While both high and low tension systems are extending in many directions, the combination high and low tension direct-current supply, or what may be called the modified "Colchester" system, devised by Mr. Frank King, is progressing with much vigour. The company have 400 30-plate accumulators of the heavy E.P.S. type, in eight sets of 50, which are charged during the day by four separately excited Brush-Victoria dynamos, driven direct by high-speed engines and joined up in series at a pressure of 2,000 volts, each machine giving 500 volts and 75 amperes. The steadiness and certainty of the supply from accumulators is appreciated, and we should suppose the high-tension charging will enable the current to be economically supplied. We understand there are now about 23,000 100-volt lamps on their books.

Magnetic Closed Circuits.—At a meeting of the Berlin Physical Society a short time ago, Dr. Dubois spoke on magnetic closed circuits, whose theory constitutes, in addition to hysteresis, the most important advance which magnetism has made in recent times. He gave a short historical review of the more important published works on the subject, pointing out that they were at first the result rather of an endeavour to make the requisite calculations connected with dynamos for technical purposes, and had only attracted the attention of physicists in a secondary and subordinate degree. The works of Faraday, Maxwell, Sir W. Thomson, Hopkinson, Lord Rayleigh, and the experimental researches of Rowland were briefly mentioned; Hopkinson's formulæ and Lord Rayleigh's graphic representations were then more fully treated; and, finally, the formula for the magnetisation of a closed circuit was developed.

Aluminium from Clay.—One of those world-revolutionising discoveries that are occasionally announced—sometimes with truth and more often without—is stated to be made by a German chemist, Prof. J. Hirsch, now living in Chicago, who asserts that he has discovered a process by which he can extract aluminium from common clay at a cost of about 7d. per pound. As the cheapest at present is some 4s., which, notwithstanding its admirable qualities, keeps it practically unutilisable in mechanics, the professor should have a fortune before him. He says he has been working at the problem since 1865, and has already secured all the financial support he requires. Premises have been taken, and he promises to commence at once turning out 300lb. a day from the start. If there is anything in the statement, a sample building in the shining metal, strong as steel and almost as light as wood, would cheer the hearts of novelty-loving architects and engineers, to say nothing of its effect in the electrical industry.

Cardiff Central Station.—The Brush Electrical Engineering Company are distributing to their customers in Cardiff a circular, intimating that they have decided to close for a time, from the 1st October next, their electric light station in Cardiff. It is their intention to considerably extend the capacity of the works, and so soon as they have obtained the consent of the Town Council to distribute the current by means of underground wires, instead of by overhead wires as heretofore. This decision is explained by the fact that the Board of Trade require the company to forthwith put the overhead circuits into conformity with their new rules and regulations. It is expected that the Town Council will recognise the useful work done by the company during the last eight years in Cardiff, and that they will not refuse their consent to the laying of the wires underground. For the transaction of all the other business, as consulting electrical and mechanical engineers, contractors for electrical apparatus, etc., the company's local offices remain in Working-street, Cardiff.

The Lighting Question at Paignton.—At the last meeting of the Paignton Local Board, Mr. Parnell moved: "That it be an instruction to the Lighting Committee to endeavour to arrange with the gas company for a test of the actual average of gas used in the lighting of the town, and to enquire as to any more effective and least expensive means of lighting than that now in public use." He complained of the high price they were paying for lamps, and while not imputing that the company wished to charge for more gas than was actually consumed, insisted that the actual quantity should be ascertained. The scope of his resolution included an enquiry as to the terms on which the gas works could be acquired by the Board, for he held that the works ought to be in the hands of the public authority as much as water. The committee would also have to enquire into other modes of lighting, whether by oil, water-gas—which seemed to have been successfully introduced into Harrogate—or electricity. Mr. Bridgman seconded the motion, which was adopted unanimously.

Mill Lighting.—Messrs. Ernest Scott and Co., electrical engineers, Newcastle-on-Tyne, have obtained the contract for the complete electric light installation for the new flour mill, at Dunston, being built by the Co-operative Wholesale Society. This mill when completed will be one of the largest in the kingdom, if not the largest, and the electric light plant, which is being put in in duplicate, will consist of two 400-light "Tyne" compound-wound dynamos, running at 600 revolutions per minute, and 466 16-c.p. incandescent lamps. The arc light installation will consist of one nine-unit "Tyne" compound-wound dynamo, with 10-ampere "Tyne" arc lamps in strong water-tight lanterns with reflectors. We hear that Messrs. Ernest Scott and Co. have a considerable quantity of work in hand of all descriptions, including a large contract for the lighting of Messrs. Arthurs and Co.'s works in Glasgow, in which two 400-light "Tyne" dynamos will be used. They are also lighting Messrs. John Bright and Bros.' mills at Rochdale, the new works of the *Bolton Evening News*, and the cold meat rooms of the Northern Counties Ice Co.

Electric Sheep Shearing Machines.—Mechanical methods of sheep shearing have long taken a practical form, and are in use in Australia on big farms. These machines (or pieces of apparatus, for they partake of the nature of horse clippers) are either direct driven with gearing, or driven with compressed air. It is suggested that the application of electricity to the sheep shearing machines would form the happiest solution of the problem, and for the man who did this a perfect fortune would be achieved. It is stated that no instance is known of an electric sheep shearer in actual use, and none were shown at the recent great contest. The judges considered compressed air machines better than the direct driven, and the direct-driven machine itself has proved very efficient. It is believed that there is a great future for electric shearing machines, but as yet there is none that can pretend to fulfil the many necessary conditions of a successful shearer. The great flexibility of the air tube, as compared with the metallic flexible direct-driven shafts, is one of the best arguments in favour of

pneumatic machines, while the necessarily clumsy shape which the employment of a cylinder necessitates is one of the chief objections to their use. An electric attachment, with small battery, might be found to combine the advantages of compactness and portability.

Lighting the Interior of the Skull.—Most of us have had the opportunity of seeing the effect of a tiny fairy, or surgical incandescent lamp, when placed inside the mouth, as now largely used by dentists, but it has possibly not occurred to users to try the effect of shutting the lips over the lamp in the dark without other lamps about. This idea has occurred to Dr. K. Vohsen, of Frankfort-on-Main, who is stated to be thus enabled to diagnose a patient, and examine certain lesions of the head with facility. We have not tried it, but give the experiences for those interested to corroborate. He employs a small incandescent lamp, one of those arranged with a double glass casing in which water can circulate. The effect of lighting, it is said, is absolutely surprising. Through the skin the bones of the head appear red, and the pupils of the eyes sparkle with a fiery colour, while the nasal sinus and the palate appear almost transparent. Under these conditions the least anomaly in any of these organs would be revealed to the physician. There is no doubt the interior of the mouth can be brilliantly illuminated by a small lamp, and so serve a doctor's purpose, but the stated transparency of the bones and palate seems a little of a joke. The power of the lamp is not stated, so that it would appear to be the ordinary surgical dentist's lamp.

Telephoning to Ships at Madras.—A Madras newspaper gives the following particulars of some experiments made recently in connecting the telephone exchange on shore with the ss. "Clan McArthur," which were carried out with the permission of the steamer's agents, Messrs. Gordon Woodroffe and Co. An ordinary wire was laid from the Madras Telephonic Exchange to the T end of the pier, a portion carried underneath the pier being covered wire. At the T end was an iron stand 3ft. high, to which was attached a drum round which was wound a coil of Glover's G.P. covered patent copper 7/16 wire, the whole cable being ½in. diameter. This cable was connected with wire from the exchange by a brass trap, which came in contact with a brass ring which moved round with the drum, being insulated from the iron portion, and both being in constant electric contact. A quantity of this cable was let into the sea slack, and after being laid under was attached to No. 1 buoy at the south end. Here the cable rose out of the water, and after passing through the ring-bolt at the head of the buoy, was carried along a hawser to the stern of the "Clan McArthur." Here there was a double connection from which a covered wire led to the saloon, this being connected with a patent desk instrument. The return wire of the instrument dropped into the sea. This completed the connection between the shore and the "Clan McArthur," which occupied about two hours, and those in the ship were able to communicate with perfect distinctness with members of the telephone exchange. The experiment was highly successful, and if sufficient encouragement is held out by the Port and Harbour Trust authorities and the merchants, it is intended to fix a cable to each of the buoys of the harbour. The desk instrument being in a portable case there is not the slightest difficulty in supplying the steamers as they come in.

Australian Cables.—The issue of the Melbourne *Evening Standard* of July 21st, just to hand, gives a vivid idea of the effect of the want of cable communication. On the morning of July 11th all three cables between Australia and Java were suddenly broken apparently about the same place, leaving a total silence between Australia and England. The effect appears to have arisen from a shock of earthquake passing over Java. The Eastern Extension Company's steamer went at once to position and buoyed the end. A long delay ensued, the Continent being cut off in ignorance as to whether the postal strike had paralysed London, or whether the Australians had won the cricket match. On Sunday, the 20th July, the welcome intelligence was sent that the joint was spliced, and that the silence which had reigned for nine days was about to be broken. On Sunday afternoon communication was established, and the great number of dispatches, official, commercial, private, and press messages which had accumulated commenced to be sent through, extraordinary editions of the *Evening Standard* being continually published till a late hour of the Sunday night. The paper next morning had five or six columns of delayed public messages. The island of Bali, between which and Banjoewangie the volcanic eruption seems to have parted the cables, is one of the Sunda Islands to the east of Java. It is a large island, and is traversed by a mountain range, the chief peak of which, Gunnungagung, over 12,000ft. in height, is volcanic. The whole of the country on the eastern as well as the western coast of Java is subject to volcanic eruptions and disturbances, and all the cables which connect Java to the headlands of Australia are within the volcanic zone. Mr. W. Croft, the manager of the telegraph office, states that the cable which was repaired was found to be broken in three places.

Cornwall Polytechnic Exhibition.—The Royal Cornwall Polytechnic Society held their annual meeting last week at Falmouth, and remains open to the end of this. Numerous interesting exhibits were shown and awards have been made in the various branches. The judges in the electrical department in their report heartily congratulate the society upon the large, varied, and important display in this section. There are practically four exhibitors: Messrs. Cathcart and Peto, of London; Mr. W. Veale, of Austell; Mr. W. Slade Olver, jun., of Falmouth; and Mr. Perrow, of Truro. A very effective 50-light dynamo, by Mr. Veale, is driven by a "Stockport" gas engine, shown by Mr. Olver, and supplies a 400-c.p. "Sunbeam" lamp in the photographic-room. Messrs. Cathcart and Peto have a very fine display in every branch of electric manufacture. Mr. Perrow makes also a decidedly good show both of instruments of his own manufacture and those of other firms. The judges recommend the award of a second silver medal to Mr. W. Veale for his dynamo made at the St. Austell Electrical Works from designs by Mr. J. M. Coon. It is admirably made, and combines great mechanical strength with very high electrical efficiency. To Messrs. Cathcart and Peto the judges of mechanics have already given a second silver medal for their admirable adaptation of the Davey model to an electric miner's lamp. The judges of electricity desire to highly commend their manufactures generally, and particularly their improved bell appliances. They award a first bronze medal for the improved switch. Mr. Perrow, who has on previous occasions obtained the medals of the society for his ingenious and effective appliances, is commended for the improvements effected and for the extent of his show. His electroliers were mentioned as especially worthy of note, and a second bronze medal is given to the new electric light shade.

Electrical Theory.—A correspondent of the *Electrical World* is greatly exercised at the upheaval of all his fundamental notions of what constitutes an electric current by the pronouncement by Dr. Duncan of "new views" upon the subject of the electric current, and he asks if there is anything in the new theory, and whether Dr. Duncan has any followers—for he is at a loss to understand the matter, and confesses to him the idea is quite new. He has the following reply, which, as it puts the said "new views" of electrical theory in a paragraph, we think some of our readers will be pleased to see: "The views referred to, as expressed by Dr. Duncan, are those held at this time by nearly all advanced electrical thinkers. The fundamental idea is that a wire carrying a current or what we call a current does not serve as a conductor in the same sense that a pipe serves to conduct water, but rather is a nucleus around and in which an electromagnetic disturbance is propagated. The idea that we must look outside the wire in considering the mechanism of an electric current is not at all new, and was the subject of an interesting discussion by Mr. Poynting some years ago. One need only look at a transformer to get a very vivid idea of the way in which electricity is not confined to the wire said to conduct it, for in this case nearly the whole energy of the current transmitted is spent outside of the wire which was once supposed to confine it. These phenomena of induction make it quite evident that the new view has much common sense on its side, and the theory of the somewhat complicated actions has been sufficiently worked out to enable us to say that any theory of the transmission of an electric current which considers only the electrical disturbance that takes place in the so-called conductor is diametrically opposed both to modern theory and to experimental facts. The idea is convenient in discussing certain classes of electrical phenomena, and reasoning based upon it is not necessarily incorrect, although it takes account of only a part of the facts."

The Steam Loop.—The dynamo efficiency being almost as high as is possible, attention must be given, if greater economy be desired, to the efficiency of the boiler-engine part of the installation. We have indicated some weeks ago the discovery announced by Prof. Thurston of a method of coating the inside of cylinder heads to save the heat of condensation. Another system of economising in this direction is having a greater success in the United States, and is known under the name of the steam loop. It is thus described: "The office of the steam loop is to cause condensed water from steam radiating pipes or from an engine to flow back to the boiler when the latter is at a higher level than the former, and it performs this seemingly impossible feat without the aid of any moving parts or the opening and closing of any valves. It is a fact well known to steam-heating engineers that when steam is flowing through a pipe it carries along with it the water of condensation, generally in the shape of a thin film on the surface of the pipe, or when a greater amount is present, in the form of short slugs or pistons, which are pushed along by the flowing steam. The working of the steam loop is dependent upon this fact, and also upon the fact that in any closed system of pipes filled with steam the lowest pressure is found at dead ends, towards which, therefore, a continual flow of steam is maintained. The steam loop is best described as a device for taking advantage of a natural 'dead end,' towards which a circulation is established by condensation, and out of which water is discharged by gravity into the boiler as fast as it accumulates. In any case the power and continuity of circulation increases the efficiency of the attached apparatus to a degree that cannot be appreciated until experimentally tried. The invention is applicable to all descriptions of steam boilers and engines; and it is claimed that in some instances its application causes 'a saving of fuel of over 50 per cent.' For heating machinery a remarkable adaptation is claimed, both by coils, pipes, and tubes, and a still higher saving than that named is said to have been saved with the same pressure at boiler in heating of large works." It is said to be a perfect substitute for the steam trap and vastly more economical. Patents for the steam loop have been secured in the United States and other countries. Messrs. Westinghouse, Church, Kerr, and Co. control the American patents, and since they put the invention on the market a few weeks ago more than 200 of these steam loops have been put into operation.

Heating Buildings by Electricity.—It having been set forth by an American technical paper that heating buildings by electricity may be expected to "banish the steam-pipes," they are somewhat sharply taken up by the N.Y. *Engineering News* over the matter. We have no doubt it was intended more particularly to refer to the heating of railway and tram cars, at present leaving the heating of the buildings till that good time coming when electricity may be generated direct from fuel and thus will be cheaper than steam. But in order to put the matter clearly in its present conditions, the above-mentioned paper has given some calculations of a building now heated by ordinary gravity return steam requiring, say, 50 tons of coal per annum. It assumes the steam plant evaporates 10lb. of water from and at 212deg. F. per pound of coal and that *all* the heat is utilised in warming, the condensed water returning at 212deg. The apparatus generates therefore $10 \times 965{\cdot}2 = 9{,}652$ heat units per pound of fuel utilised in heating. For an electrical generator, the boiler and engine are taken as giving 1 brake h.p. for 2½lb. of coal per hour. The electrical efficiency of dynamo and line circuit is taken at 85 per cent., and it is assumed, for argument, that all the electricity is converted into heat. This ·85 e.h.p. gives 1,683,000 foot-pounds energy per hour, or 2,180 heat units. This is for 2½lb. of coal; and for 1lb. it will be 872 units against 9,652 by steam heating, or about as 1 to 11: so that 550 tons of coal will be required instead of 50 tons, or, with utmost fuel economy yet reached, at least 300 instead of 50 tons. Then as to size of plant. The maximum capacity of the steam heater using 50 tons a year should be not less than $\frac{7}{8}$ of a ton in 12 hours to furnish steam for the coldest days. Taking 9,652 units per pound, this gives 1,407,582 heat units per hour. The electrical plant gives 2,180 units per brake h.p., therefore the total brake h.p. of engine will be 1,407,582 units divided by $2{,}180 = 645$—that is, boilers, engine, and dynamos sufficient to generate, say, 650 h.p. The cost of this, it needs but an elementary knowledge to see, would render the whole scheme ridiculous, to say nothing of the size and cost of copper, cost of operating, wages of engineers, firemen, and others that would be required. The above calculations are interesting and we give them for the sake of the example they contain, but it also needs but little knowledge to know that no electrical engineer would be likely to propose heating by electricity on any but the smallest, and handiest, and (from this) serviceable scale while the cost of generating electricity remains what it is. The field is nevertheless a very large one when once the problem of direct generation has been solved, but one, until then, that is out of the range of practical politics.

ON CURRENT DISTRIBUTION IN NETWORKS OF ELECTRICAL CONDUCTORS.*

BY J. HERZOG AND L. STARK, BUDA-PESTH.

In a previous paper we communicated a simple method on the predetermination of current distribution in a given network of electrical conductors, consisting essentially of the following operations: The network, Fig. 1, is opened or cut at suitable branching or nodal points in such a way as to be completely dissolved into open networks, each of which remains, however, in connection with the feeding source, either directly or indirectly. Imagine any conductor

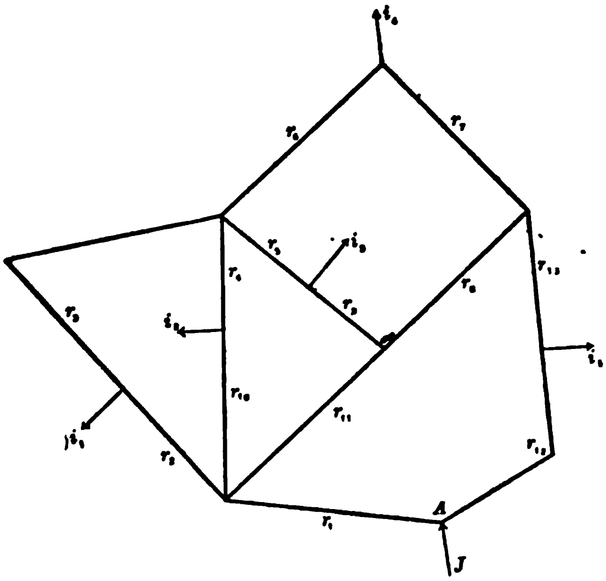


FIG. 1.

cut at a point where a current, i, is tapped. The two parts of the conductors near the cut will then be passed by currents x_1 and $i - x_1$ respectively. Thus, each cut forms an unknown quantity, and also an equation for the same, expressing that the loss of potential from any feeding point to the cut is the same, whatever way we may choose, from

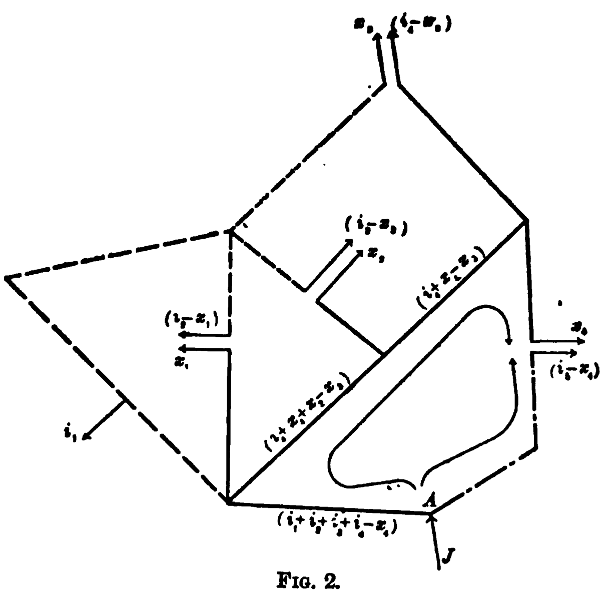


FIG. 2.

the former to the latter. For the unknown x_4, Fig. 2, we obtain:

$$(i_1+i_2+i_3+i_4-x_4)\, r_1 + (i_4+x_2-x_3+x_4)\, r_{11} + (i-x_3+x_4)\, r_8 + x_4\, r_{13} = (i_5-x_4)\, r_{12}.$$

It will be noted that in these equations the unknowns are multiplied by coefficients which are linear functions of the resistances of the conductors. Those quantities in the equations which are not coefficients of any of the unknowns are sums of products of known consumed currents into linear functions of the resistances of the conductors.

Denoting the coefficients of the unknowns by $(a_{11})\ldots\ldots(a_{nn})$ and those of the consumed currents by $(r_{11})\ldots\ldots(r_{nm})$, these equations may be written as follows:

$$\begin{aligned}
(a_{11})\,x_1+(a_{12})\,x_2+(a_{13})\,x_3+\ldots &= (r_{11})\,i_1+(r_{12})\,i_2+\ldots\\
(a_{21})\,x_1+(a_{22})\,x_2+(a_{23})\,x_3+\ldots &= (r_{21})\,i_1+(r_{22})\,i_2+\ldots\\
(a_{31})\,x_1+(a_{\ 2})\,x_2+(a_{33})\,x_3+\ldots &= (r_{31})\,i_1+(r_{32})\,i_2+\ldots\\
\ldots\ldots\ldots\ldots\ldots &\quad \ldots\ldots\ldots
\end{aligned}$$

Hence

$$x_1 = \begin{vmatrix} [(r_{11})\,i_1+(r_{12})\,i_2+\ldots], & (a_{12}), & (a_{13})\ldots\\ [(r_{21})\,i_1+(r_{22})\,i_2+\ldots], & (a_{22}), & (a_{23})\ldots\\ [(r_{31})\,i_1+(r_{32})\,i_2+\ldots], & (a_{32}), & (a_{33})\ldots \end{vmatrix} : \begin{vmatrix} (a_{11}), & (a_{12}), & (a_{13})\ldots\\ (a_{21}), & (a_{22}), & (a_{23})\ldots\\ (a_{31}), & (a_{32}), & (a_{33})\ldots\\ \ldots & \ldots & \ldots \end{vmatrix}$$

Similar expressions result for the other unknowns, differing only in the numerators, the denominators being the same and depending only upon the resistances and the configuration of the network. The determinant forming the numerator may be split up into a sum of determinants:

$$i_1 \begin{vmatrix} (r_{11}), & (a_{12}), & (a_{13})\ldots\\ (r_{\ 1}), & (a_{22}), & (a_{23})\ldots\\ \ldots & \ldots & \ldots \end{vmatrix} + i_2 \begin{vmatrix} (r_{12}), & (a_{12}), & (a_{13})\\ (r_{22}), & (a_{22}), & (a_{23})\\ \ldots & \ldots & \ldots \end{vmatrix} + \ldots$$

or in words: Current x_1 may be viewed as the sum of all the currents produced by gradually tapping in the consumed currents, one by one, all the rest of them being supposed zero. Precisely, this theorem of the superposition of the consumed currents may be formulated as follows:

"The current in any branch of a network due to the consumed currents taken off in various branches is the algebraical sum of the currents in that branch due to each consumed current considered separately, all the others being supposed zero."

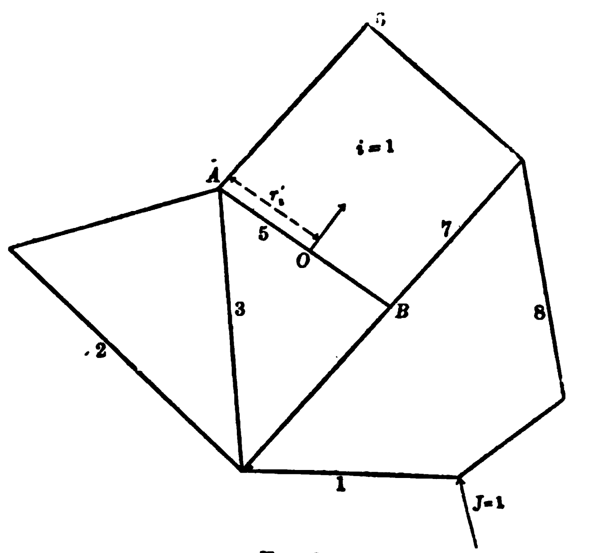


FIG 3.

This rule may also be derived from the well-known theorem of superposition of E.M.F.'s by replacing each current-consuming device of resistance, r, and current, i, by a counter E.M.F.: $e = E - i r$, E being the E.M.F. of the source.

These two theorems of superposition are nothing but expressions of the fact, evident in the linear character of the equation, that the problem of current distribution is univocal.

The theorem of the superposition of consumed current offers more than a theoretical interest; in fact, it provides a convenient means of solving many questions that arise during the development of a central station.

The network of such a station is chosen for some probable current distribution. This distribution has often to undergo essential variations even during installation; certainly such

* From the *Electrical World*, New York.

variations will take place in daily and monthly or seasonal periods. Besides, the development of the central station will also enlarge and displace the currents consumed. Of course, the influence of these different variations upon the load on the conductors and the amount of loss of potential could be kept in evidence by setting up a corresponding number of new equations and making tiresome evaluations.

But our theorem affords the means of constructing in advance graphical or numerical tables, from which the desired results may be gathered.

At any one of the nodal points of the network, imagine one single derivation equal to any suitably chosen amount, say, 1, 10, 100, or 1,000 amperes, all the others being supposed zero, and for this single consumed current arrange the system of linear equations after having made a suitable number of cuts. Next, place this consumed unit at the next nodal point and let it thus wander through all the nodal points of the system. Then, the number of the resulting systems of equations will equal that of the nodal points of the network, and the current distribution may be determined for each position of the consumed unit. At first glance this seems to be a rather troublesome task; the work is, however, essentially shortened and simplified by the fact that for all unknowns, throughout all systems of equations, the denominator determinant is the same, the numerator for any unknown throughout all the equations having as constituents always the same sub-determinants.

Consider any conductor, A B, in a network of n conductors with the consumed unit placed at its end, A. Then there will be n currents $(x_n)_A$ in the conductors due to this

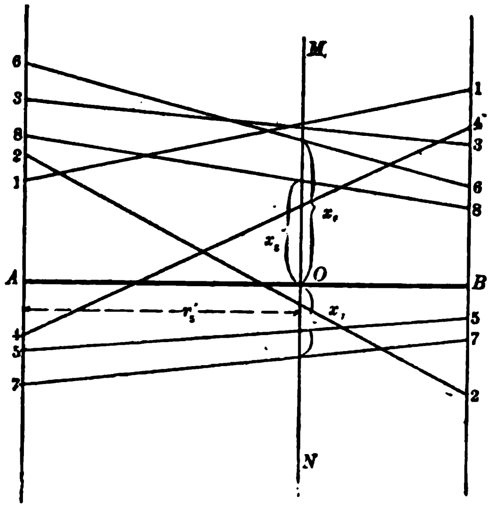


FIG. 4

one derivation. Next, imagine this derivation equal to the unit to be taken at the other end, B, of the conductor, then the n conductors will be passed by n other currents (x_n). Now we are enabled to design a graphical scheme for this conductor of the network containing as horizontal base line the conductor itself on the scale of its resistance, and as ordinates at each end, A or B, all the currents $(x_n)_A$ and $(x_n)_B$—taken with their signs respectively.

To discuss the network in Fig. 3 completely, eight tables, one for each conductor, would be necessary. One of them, belonging to conductor 5, is represented by Fig. 4. Here

$\overline{A1} = (x_1)_A$ $\qquad$ $\overline{B1} = (x_1)_B$

$\overline{A2}$

. . . . $\qquad$ $\overline{B2} = (x_2)_B$

. . . .

$\overline{A8} = (x_8)_A$ $\qquad$ $\overline{B8} = (x_8)_B$

Now join the ends, $n\,n$, of corresponding ordinates $(x_n)_A$ $(x_n)_B$ by a straight line, $n\,n$, and at any point O of A B draw a perpendicular upon the base line, intersecting $n\,n$ at N. Then, O N is easily shown to be the current in conductor n, due to the current unit being branched off at point M of conductor A B. To prove this it is only necessary to show that the equation joining x and r' is that of a straight line. Now r' can be contained only in the equations that consider the whole loss of potential e from A to B, Fig. 5. This loss is

$$e = x\,r' - (i - x)(r - r') = i\,r' - i\,r + x\,r,$$

which is the equation of a straight line. In analogy to a similar curve in graphical statics this line may be called the influence line.

Imagine the real current supply to be such that at various points of a certain conductor the consumed currents i_1, i_2, i_3 . . . are tapped; at each of these points draw perpendiculars upon the base line and multiply each segment, produced by intersection with the influence line by

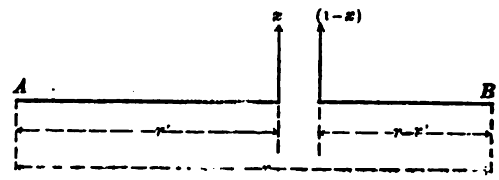


FIG. 5.

its corresponding current, taken in the suitable unit. Add the resulting currents that belong to one and the same conductor and proceed in a similar way with all the other tables.

Then, according to the theorem of the superposition of currents, the load on any conductor due to the simultaneous supply of all the current consumers will be obtained by adding all the currents for this conductor gathered from all the tables. Obviously, the influence of any additional current consumer can be found out from the tables in a similar way.

In practice we generally have two forms of current supply—viz., for concentrated loads, which act at distinct points, and for distributed ones, which act over a continuous length of the conductor. Reducing corresponding distributed or concentrated loads to one concentrated load simplifies the predetermination of current distribution in a high degree. In fact, several concentrated loads or a distributed one between any two neighbouring nodal points may be reduced to one concentrated load equal to the algebraical sum of these loads, and tapped from the common centre of gravity. The current distribution will be the same for the whole network, whether the reduced load or all the loads not reduced are taken into consideration; only the part of the conductor between the first and the last of the loads that have been gathered will not be equally loaded in both cases; it is, however, an easy matter to calculate the real currents for these parts of the conductor, the distribution in the rest of the network being found out beforehand by means of the reduced load.

That the resulting load passes the centre of gravity may be deduced from the analogy between the momentum of a current and a force. Nevertheless we will show the validity of this rule.

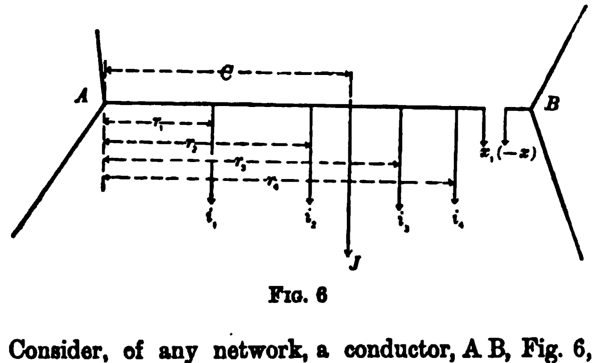


FIG. 6

Consider, of any network, a conductor, A B, Fig. 6, at various points of which currents $i_1, i_2,$ . . . are branched off; let $r_1, r_2,$ . . . denote the resistances of the conductor from it to these points. Put R_1 for the sum of all the resistances that lie between A and the source, and are passed by the sum of the consumed currents, $i_1, i_2 +$ . . . and let R_2 stand for the sum of all the resistances between B and the source. Let V_1 and V_2 be the losses of potential

from the source to A and B respectively that are due to the rest of the currents in the conductors. Then,

$$i_1(r_1+R_1)+i_2(r_2+R_1)+\ \ldots\ +x(r'+R_1)+V_1=$$
$$=-x(r''+R_2)+V_2,$$

which equation remains unaltered if, instead of

$$i_1(r_1+R_1)+i_2(r_2+R_1)+\ \ldots$$

we write $J(\varsigma+R_1)$, where $\varsigma=\frac{\Sigma(ir)}{\Sigma i}=\frac{\Sigma(ir)}{J}$.

No further proof is necessary to show that the same rule may be applied for the reduction of distributed loads. The usual statement of this distributed load per current meter, however, must first be reckoned over into one per current unit of resistance.

Doubtless it is of the highest importance to know how many equations are necessary—that is, how many cuts are to be made to make the problem determinately soluble. In the following we will show that it is necessary and sufficient to put down as many equations as there are closed meshes contained in the network. Consider, as an example, the network in Fig. 7. Cut each of its four meshes at one place, and to avoid indistinctness reckon all the currents circulating counter-clockwise round any mesh as positive with regard to this mesh. Then, of course, a current in the boundary conductor between two meshes will have

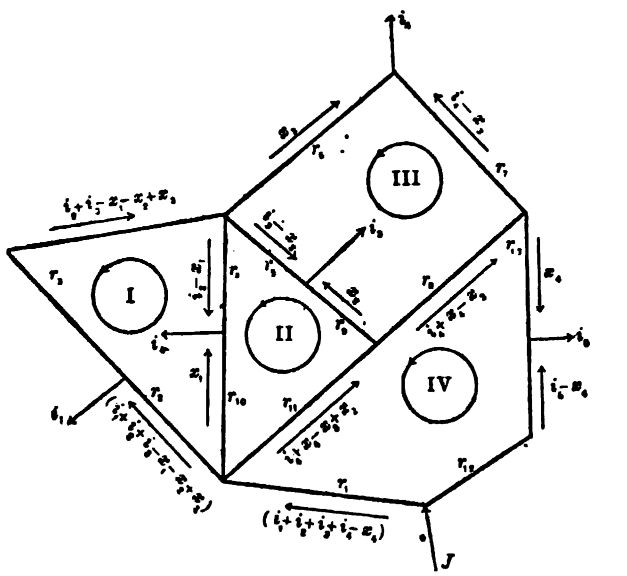


FIG. 7.

opposite signs with regard to these meshes. For each of the four cuts we can, then, write down an equation expressing that the algebraical sum of all the losses of potential taken with their respective signs equal zero. These four equations are:

$$-(i_3-x_1)r_4-(i_2+i_3-x_1-x_2+x_3)r_3-(i_1+i_2+i_3-x_1-x_2+x_3)r_2+x_1r_{10}=0 \qquad \text{(I)}$$

$$-(i_3-x_2)r+(i_3-x_1)r_4-x_1r_{10}+(i_4+x_4-x_3+x_2)r_{11}+x_2r_9=0 \qquad \text{(II)}$$

$$-x_2r_9+(i_4+x_4-x_3)r_8+(i_4-x_3)r_7-x_3r_6+(i_3-x_3)r_5=0 \qquad \text{(III)}$$

$$-x_4r_{13}-(i_4+x_4-x_3)r_8-(i_4+x_4-x_3+x_2)r_{11}-(i_1+i_2+i_3+i_4-x_4)r_1+(i_5-x_4)r_{12}=0 \qquad \text{(IV)}$$

Certainly these four equations suffice to calculate all the unknown currents. From this we may reason that for a network of any number of meshes the number of cuts must equal that of meshes, each mesh containing at least one cut. Cutting the network in Fig. 7 at any one more place, i_1, Fig. 8, only apparently alters the number of unknowns, each new unknown, y, being predetermined by the former four unknowns.

$$-y=i_2+i_3-x_1-x_2+x_3.$$

The theorem of the superposition of currents showed the number and form of the equations to be independent of the number of consumed currents. To discuss the number of equations necessary it is, therefore, sufficient to assume only one consumed current. This simplification will serve to place networks in the form of a more general conception created by Maxwell and published by Prof. J. A. Fleming in a paper read before the Physical Society on June 27, 1885, the knowledge of which we owe to the kindness of the author.

"Consider a network, Fig. 9, containing five meshes or cycles. Now let an E.M.F. act in one branch, B, and give rise to a distribution of currents in the network. Let $\alpha, \beta, \gamma, \delta$ represent the potentials at the nodal points, and A, B, C, D the electrical resistances of the conductors joining these points, and imagine that round each cycle an imaginary current flows, all such currents flowing in the same direction.

"A circuit is considered to be circumnavigated positively when you walk or go round it so as to keep the boundary on your right hand. Hence going round an area, A, Fig. 10, in the direction of the arrow is positive as regards the inside if you walk inside the boundary line, and negative as regards external space if you walk in the same direction round the outside. We shall consider a current, then, as positive when it flows round a cycle in the opposite direction to the hands of a watch. The real currents in the conductors are the differences of the imaginary currents in adjacent cycles or meshes.

"Let x, y, z . . . denote these imaginary like-directed currents. Then $(x-y)$ denotes the real current in the branch J, and similarly $(x-z)$ that in branch H. Then x,

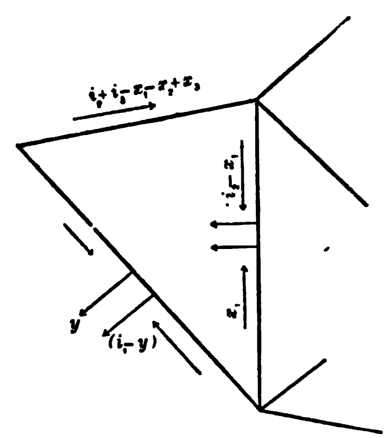


FIG. 8.

y, z may be called the cyclic symbols of the areas. The cyclic symbol of external space is taken as zero—hence the real current in B is simply x.

"Applying Ohm's law to the cycle x formed by the conductors, B, J, H, we have for these three conductors

$$\gamma-\alpha=E-Bx$$
$$\gamma-\beta=(x-y)\ J$$
$$\beta-\alpha=(x-z)\ H.$$

"Adding together these three equations, we obtain

$$E=x(B+J+H)-yJ-zH.$$

"This equation is called the equation of the x cycle, and we see that it is formed by writing as coefficient of the cycle symbol, x, the sum of all the resistances which bound that cycle, and subtracting the cyclic symbol of each neighbouring cycle multiplied respectively by the common bounding resistance as coefficient, and equating this result to the effective E.M.F. acting in the cycle written as positive or negative according as it acts with or against the imaginary current in the cycle. This is Maxwell's Rule."

In this way we can form as many independent linear equations as there are meshes, and therefore unknown cyclic symbols, the real current being differences of these imaginary currents.

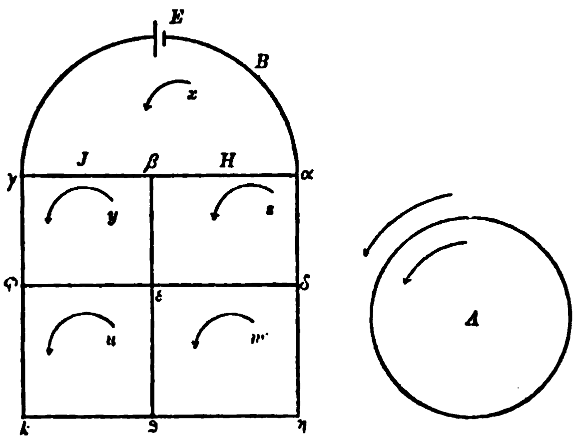
From this general network problem it is easy to pass to a more special one dealing with a network for lighting purposes where the current-consuming devices are connected in parallel between two half-nets. As we can discuss

the equations without dealing with more than one consumed current, we may draw the network of Fig. 1 as is shown by Fig. 11, retaining of the consumed currents only i_4. Consider two half-nets having n meshes each; then there will be $2n+1$ cycle currents in total, one of which, namely, that in the cycle of currents consumed, is known. In consequence of the equal configuration of both half-nets the remaining $2n$ unknowns come down in number to n.

For networks of relatively few meshes the evaluation of n unknown from n linear equations will be conveniently made by means of determinants. The work is greatly shortened by the relatively high number of zeros that ordinarily occur in these determinants. By suitably interchanging some rows or columns it is possible to crowd most of the zeros in one corner, and then, according to Laplace's rule, the given determinant equals the product of two determinants of lower order.

$$\begin{vmatrix} r_{11} & r_{12} & \cdot & r_{13} & r_{14} & r_{15} \\ r_{21} & r_{22} & \cdot & r_{23} & r_{24} & r_{25} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & \cdot & r_{33} & r_{34} & r_{35} \\ 0 & 0 & \cdot & r_{43} & r_{44} & r_{45} \\ 0 & 0 & \cdot & r_{53} & r_{54} & r_{55} \end{vmatrix} = \begin{vmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{vmatrix} \times \begin{vmatrix} r_{33} & r_{34} & r_{35} \\ r_{43} & r_{44} & r_{45} \\ r_{53} & r_{54} & r_{55} \end{vmatrix}$$

It may, however, happen that even after this reduction the remaining determinants are of a very high order, requiring, therefore, much work and time for solution. For any determinant of the nth order consists when evaluated of $n!$, *i.e.*, $1.2.3. \ldots (n-1). n$ elements. Considering that, therefore, the work for the evaluation of one unknown will be proportional to $2n!$, we will look out for



FIGS. 9 AND 10.

some shorter and less troublesome method of solution, even if it be only an approximate one. It is an interesting fact that similar requirements have been found in other branches of science as high as 86; Bessel's measurement of degrees required the evalution of 70, Seidel's series of astrophotometric researches that of 72 unknowns. The latter mathematician invented, for similar reckonings, some approximate methods of evaluations, whose essential features we will give below without entering upon any proof, which may be taken from the original paper.* The equations to be solved are:

$$\left.\begin{aligned} a_1 x + b_1 y + c_1 z + \ldots + n_1 &= 0 \\ a_2 x + b_2 y + c_2 z + \ldots + n_2 &= 0 \\ a_3 x + b_3 y + c_3 z + \ldots + n_3 &= 0 \end{aligned}\right\} \quad . \quad \text{(A)}$$

Inserting
$$a_1^2 + a_2^2 + \ldots = [aa]$$
$$a_1 b_1 + a_2 b_2 + \ldots = [ab] = [ba]$$

We can put down the following system of standard equations:

$$\left.\begin{aligned} [aa]x + [ab]y + [ac]z + \ldots + [an] &= 0 \\ [ab]x + [bb]y + [bc]z + \ldots + [bn] &= 0 \\ [ac]x + [bc]y + [cc]z + \ldots + [cn] &= 0 \end{aligned}\right\} \quad \text{(B)}$$

From these equations the unknowns may be found as follows: Assuming any system of numerical values for the unknowns, $x, y, z, \ldots$ they will, of course, not fulfil the standard equations, but will make

$$[aa]x + [ab]y + [ac]z + \ldots + [an] = N_1.$$
$$[ab]x + [bb]y + [bc]z + \ldots + [bn] = N_2.$$
$$[ac]x + [bc]y + [cc]z + \ldots + [cn] = N_3.$$
. . . .

Now we can improve the value of one of the unknowns; for instance, x, changing it by $\Delta x = -\frac{N_1}{[aa]}$.

This will make $N_1' = 0$. And the improved value, $x + \Delta x$, will now be such a value of the first unknown as to suit best the preliminarily chosen values of the other unknowns; it would be the most plausible value if the rest of the preliminary values were right.

The variation of x, which changes N_1 into $N_1' = 0$, has also an influence upon $N_2, N_3 \ldots$

$$N_2' = N_2 + [ab], \Delta x$$
$$N_3' = N_3 + [ac], \Delta x$$
. . . .

Now, we can correct y by adding $\Delta y = -\frac{N_1'}{[bb]}$.

Instead of $N_1' = 0, N_2' N_3' \ldots$ we will then have
$$N_1'' = N_1' + [ab]$$
$$N_2'' = N_2' + [bb]\Delta y = 0$$
$$N_3'' = N_3' + [bc]\Delta y$$
. . . .

As a third correction we might change Z by a value making the new value $Z + \Delta Z$ suit as well as possible the

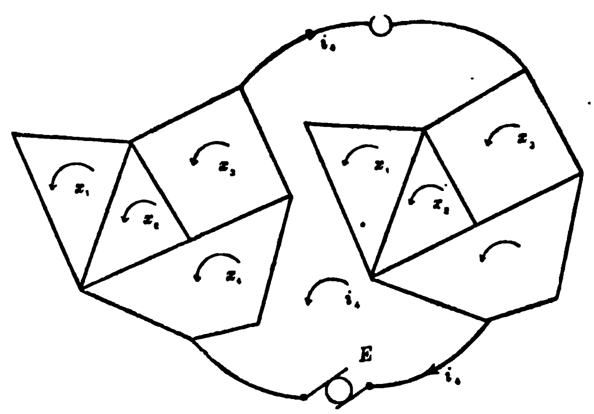


FIG. 11.

system which is formed by $x + \Delta x, y + \Delta y$, and the preliminary values of the remaining unknowns. We would then obtain $N_3''' = 0$. Just as well, however, we might return to x, changing it by $-\frac{N''}{[aa]}$ thus making $N_1''' = 0$.

As soon as these corrections of any unknown are made in such a way as to fulfil that standard equation, in which the unknown in question occupies the favourite position in the diagonal of the system of equations, we must obtain a converging approximation toward the real values, no matter in which order these corrections are performed. The corrections are repeated until all the N's are brought upon infinitely small values.

Obviously, the time required for total solution is the less the nearer the assumed values are to the real ones. This is a great advantage of the method for the purpose of evaluating current distribution in networks, as with some practice it is easy to make good assumptions for the values of the unknown currents by considering the configuration of the network and the consumed currents.

Hot Weather and Motors.—The electric motors on some of the American railways are said to suffer more even than the men with a wave of hot weather, and before the close of a hot day some of the cars have to be left on one side to cool, the armatures get so warm.

* Ludwig Seidel, Abhandlung der Math. Phys. Classe der Bayer Akademie 11, Bd. 1874.

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THE PRESIDENTIAL ADDRESS.

As year succeeds year it must become more and more difficult for the president-elect of the British Association to decide upon the subject of his inaugural address. No matter what the decision may be the result will surely call forth adverse criticism. If scientific and special, then it is out of place for an audience that is mixed and principally consisting of non-scientific elements. If it is general and understandable of the multitude, the strictly scientific element moans and sighs at the degeneracy of the modern meeting, and, like all of us who are monomaniacs, compares the present unfavourably with the past. The moan we often hear about the good old days and nothing like them simply means that the worshipper of such days has slept since he reached years of manhood, has been passed by the rising generation, but is utterly unable to understand that the younger generation is progressing while he is standing still. Sir F. A. Abel's presidential address ought to open the eyes of such people. It rapidly describes the progress during the past decade of scientific thought and discovery. It shows there is no standing still, but a constant movement—a movement we all believe is forward. In many directions the movement must be characterised as a rush; and it is extremely difficult for anyone in the midst of the bustle to say the value of the day-by-day work. The only means of ascertaining such value is to compare the position now with the position ten, twenty, fifty, or a hundred years ago. Much that is flaunted in our eyes from day to day takes no place in the onward movement; it is found, tried, found wanting, and flung aside with as little compunction as the shell from the kernel. We contend, then, that it is wise from time to time for someone to calmly and deliberately put before us a sketch of recent scientific progress. Sir F. A. Abel has done it in his present address, the period for examination seeming to be principally that which has elapsed since the last meeting at Leeds. The man who prides himself upon being a leader in some particular branch of science will probably not read the address; but he who is not so placed will look to it to give him a compendious account of the present position of science. The branch of science that is progressing by leaps and bounds is electricity. The president says it is the one "in the practical applications of which the greatest strides have been made since the association met at Leeds in 1858." That year saw the first cable laid between Europe and America. It failed, but what of that? Failure in such a case laid the foundations to success; and though the glamour of lighting and power transmission attracts the greatest attention the incomparable value of submarine telegraphy cannot be forgotten. It has revolutionised the trade, the national politics, and almost the social customs of the world—

hence, in a review of this kind takes the first place. The names of Gray, Volta, Ampère, and others may live through the ages, but a greater than these lives in our midst. Thomson made submarine telegraphy practicable; and even were his practical and scientific works confined solely to this his name would last as long as literature endures or the English language remains. But it is not only submarine telegraphy that has progressed. On land we have seen simplex succeeded by duplex, and duplex by quadruplex, and quadruplex by multiplex sending, till one hardly realises or, in fact, knows what can and what cannot be done. The telegraph system in this country is the monopoly of the Government, and as such liable to be adversely criticised by everybody; yet it is safe to say no critic can show a country wherein the mechanical details of telegraphy are carried to greater perfection. Thanks to the energy of Mr. W. H. Preece, the scientific, and especially the British Association, public is kept fairly conversant with telegraphic progress, and that of its rapidly-growing baby, telephony. Sir F. Abel refers to the numerous branches of electrical application that have sprung up: transmission of power; welding and fusing of metals; in metallurgical operations such as the production of aluminium bronze, ferro-aluminium, and silicium bronze, also aluminium alloys—not forgetting electric lighting. With regard to the latter we are told that in April this year there were in use in America 235,000 arc lamps and about 3,000,000 incandescent lamps, while in England there are about one-hundredth the number of arc lamps and about one-tenth the number of incandescent lamps. Sir F. Abel attributes this result somewhat to indifferent legislation. We will not differ with him, though many supplementary things have contributed towards this result. He considers the delay has really been in the interest of intending suppliers and users of the electric light, and looks forward to the ample lighting of the metropolis on a really sound footing.

No doubt other portions of the address, not referring to electrical matters, will be found interesting, but to these we shall only briefly allude. The progress in our knowledge concerning alloys, concerning powder (smokeless and otherwise), is admirably described, while that part of the address devoted to the development of the petroleum industry merits attention. Perhaps it will be held that only the last few paragraphs are of a controversial character. These refer to educational matters, and it is well known that here the greatest diversity of opinion exists. Many men place little value on museums and the Imperial Institute, while many others hold a different estimation of their value, and expect to see Kensington in a few years take a high position as a centre of scientific activity. The future, and the future alone, can tell how far the aspirations of the energetic founders of these institutions will be realised, but we may all hope that the result will be better even than their anticipations.

THE PINCH OF RIVALRY.

The gas companies in England and America have not yet much felt the pinch of the electric competition—the latter because they have in many cases adopted the new light, the former because the progress in this country has been slow, and the spread of gas has more than kept pace with the filching of their customers. But this has not been the case in foreign countries, and the latest report of the executive of the gas company in Gand sounds a note of lamentation. Already many, if not most, of their best customers are gone, either by their adherence to the direct supply or their purchase of arc lighting apparatus driven by themselves. The gas company has felt it necessary to make further and further reductions at a cost last year of 26,000f., and a prospective one next year of 35,000f. It will be necessary, mournfully concludes the report, to seriously consider this question, as it is a vital matter to the company. We may feel a certain sympathy with companies and their human directors when the force of circumstances and the evolution of newer and better methods begin to press with inevitable force, but both as pioneers of electrical industry, and as part of a public who will only too joyfully accept a better and cleaner light, we must be pleased to see that the question has become a "vital" one.

HOW TO ESTABLISH A CENTRAL ELECTRIC LIGHTING STATION.

BY SYDNEY F. WALKER.

(Concluded from page 164.)

Then as to the form of the charge and its amount. Undoubtedly the charge by meter is by far the best, as it leaves the whole of the lamps completely at the disposal of the consumer, without much chance of dispute. He may grumble at his bill, just as he does at his gas bill, but he will pay, just as he does now. While, however, meters are establishing themselves and gaining a position which shall make their record unassailable, it may be useful to have another method of charging. The simplest plan is, of course, to let a consumer have the use of the current whenever he likes, either for the full 24 hours or for certain hours during the day. This plan, however, is open to the objection that it is unfair to the small consumer, and may prevent a number of these adopting the light, and thereby adding considerably to the revenue of the station, as a higher rate can usually be obtained in proportion from small buyers than from large ones. The difficulty that would naturally suggest itself, that consumers would leave their lamps burning has been met already by the simple expedient of allowing them to supply their own lamps, and warning them that every hour they are used when not required is so much extra to their total lighting bill. While, too, the demand for electric light is as at present everywhere in excess of the supply, the difficulty of charge may not be felt, but where it is felt the writer suggests the following solution.

Divide up the mains as already described, and connect consumers to different sets of mains according as they require, from 4 p.m. to 6 p.m., from 4 p.m. to 8 p.m., to midnight, or all night. Even different lights in individual houses may be placed on different supply mains. Then shortly after 6 p.m., 8 p.m., midnight, or 7 a.m. next morning cut off the supply from each set of mains in succession, allowing 10 or 15 minutes so as to avoid disputes owing to differences in clocks. Later on, when meters can be relied on, and are not sold at a prohibitive price, there will not be much difficulty in rearranging matters, and that without altering the connections, except so far as may be necessary to insert the meter, and the system will still have the great advantage that all eggs are not in one basket. Lastly, as to the amount of the charge for supply. Do not make this too low at first. You can always reduce, when your experience of working has shown that you are able to do so without loss, but remember, no matter how carefully you may estimate, nor how far-seeing you may be, only actual working for *several* years can show you what your running expenses are going to be. A skilled engineer who is careful will be able to save numerous outgoings by much thought; but no engineer, however skilful, or however experienced, can be quite sure of guarding against everything. Therefore, leave a margin in your estimate of maintenance cost for unforeseen contingencies, especially under the item of repairs to cables; and to enable you to do this, put your selling price as high as you can short of driving the bulk of the business away. There is a strong temptation to fix prices at a low figure in order to compete with gas and to get a large supply. It is a most unwise policy. The electric light, to be supplied as surely as gas, cannot compete with it in price, and to attempt to do so is only to court failure.

Further, the light is worth more than gas, just as gold is worth more per pound than silver. And just as people who use gold are prepared to pay a higher price for it than for a similar article made of silver, so will those who appreciate the steadiness, the healthiness, and the beauty of the electric light be prepared to pay a fair price for it. Further, in all new things that are introduced you do not get to the general consumer at once. You first reach an inner circle, specially circumstanced, who either do not mind paying the extra price—the luxury price—or to whom, owing to their special conditions, the advantages of the apparatus more than outweigh the additional cost. Hence, from this circle, a comparatively high price is obtainable. Outside these stand a second circle, not so ready to pay, not so peculiarly situated; but who will adopt the new thing if either it comes down to a certain figure, or they can see that others are reaping an advantage from it? The experience gained with the inner circle, properly applied, enables the next circle to be reached both in price and in the other requisites. This leads to a third circle, and so on, until the cost of the new apparatus is actually reduced below that of the apparatus it displaces. This is the writer's experience with electrical apparatus, and that not in one or two cases, but in every case which has passed through his hands.

Lighting, however, stands in this unique position, that it has not been necessary, apparently, for gas to come down to the price of oil in order to supersede the latter. To-day, and, in fact, ever since gas has been in use, the cost of lighting with petroleum lamps has always been about one-fifth that of the same lighting by gas; yet the latter has flourished, and, strangest of all, the consumption of oil and candles has also enormously increased.

Our grandmothers were content with two mould candles. We are not satisfied with a gas-burner stated to give 14.

In conclusion, the writer would warn intending openers of central electric lighting stations not to forget the cost of their provisional orders. It may be placed to capital account, as the cost of a patent would be, or to revenue; but do not forget it. And, further, allow an item, in sundries if you like, for disputes, legal charges, etc. If you have no breakdowns you are sure to meet with cantankerous consumers, with men and women who are thoroughly imbued with a proper sense of the beauty of the electric light, but who regard it as not far short of a providential dispensation that they should have it for nothing, like Artemus Ward's Mormon visitors. These people are a nuisance, but you must reckon with them. Put something in your estimate for them. You will be that much to the good if they don't call for it.

THE "HEDGEHOG" TRANSFORMER.

Last year Mr. James Swinburne brought forward the theory that an open iron circuit could be made more efficient than any form of closed iron circuit transformer. The loss in a transformer is made up of loss in copper due to resistance and loss in iron due to hysteresis. In calculating the efficiencies of transformers, the loss in the iron has generally been left completely out of account, and the loss in copper alone considered. Hence efficiencies of 97 and 98 per cent. are claimed for closed iron circuit forms. If the loss by hysteresis is taken into account, allowing the losses as given by Ewing, the loss in iron closed circuit transformers as usually designed is some 10 per cent. of the full load. As the loss in iron goes on all the time a transformer is in circuit, this is very serious. The proportion of actual to possible output of energy per day varies in different districts, but in most stations the average use of lamps is less than two hours a day, including all the lamps installed. The transformer must be large enough to feed all the lamps installed, so it runs, say, an average two hours of full load a day. If there is a loss of 10 per cent. of full load in the iron, this gives an actual efficiency of 45·5 per cent., even neglecting the loss in copper. In the hedgehog form the proportion of iron is very much reduced. The cross-section of the iron is much less, and the length is about one-third of that of the closed circuit form, as it has not to surround the wire. The result is that, even in small transformers, the iron loss is under 1 per cent. of the full load. One per cent. of full load gives 89 per cent. all day, neglecting copper loss, against the 45 per cent. of the closed circuit. This is neglecting copper, however, and the copper loss is greater in the hedgehog form, so this is an exaggerated comparison. Such a transformer really has an efficiency of about 87 per cent. all day.

Fig. 1.—Transformer in Case.

Fig. 2.—Transformer with Case Removed.

The theory of the hedgehog form is this: If a closed iron circuit is used, the iron circuit must be long to embrace the copper coils. The only way to shorten it is to make the copper coils smaller. This means using a higher current density, which is wasteful, or fewer turns of copper, which demands either a higher induction in the iron or a greater cross-section, and both of these mean greater loss of hysteresis. If the iron circuit is opened, three sides of the embracing core can be removed, so the loss by hysteresis is divided by three. As there is now plenty of room for copper, the turns and cross-section can be increased, and the iron reduced still further. The object of introducing the closed iron circuit was to reduce the magnetic resistance. An open circuit transformer has much higher magnetic resistance. The question of magnetic resistance is not so important as might at first sight appear. Its increase demands more excitation, or more magnetomotive force, and this increases the loss in

copper. The best form is thus a compromise. The hedgehog ends are to reduce the magnetic resistance. In a conductive circuit the resistance is low if the current density is low in all parts where the specific resistance is high. Similarly in a composite magnetic circuit of iron and air, the magnetic resistance is low if there is never a high "magnetic current density," or induction in the air, which has high specific magnetic resistance. The magnetising current in a hedgehog is high, but as it is quarter of a period behind the primary current in phase, and as the primary wire has to be large enough to carry the primary current, the loss in watts is small. As this loss goes on all day, however, it is by no means unimportant, and has to be included in getting out the efficiencies.

The construction of these transformers, Figs. 1 and 2, by Messrs. Swinburne and Co., of Teddington, is very simple. A gunmetal casting of cross-shaped section forms the backbone. It is spread out at each end, forming legs at one, and taking circular terminal boards at the other. It also carries insulating flanges which form the ends of the coils. Into the four recesses in the core are put four bundles of soft iron wire. These are taped over, and the secondary is wound on. The secondary is then covered with two layers of ebonite, and the flanges are also faced with the same material. The primary is then wound on in two compartments, separated with ebonite after the manner invented by Gramme, so that both ends come outside, and as far removed from each other as possible. The ends of the core are then spread out and the transformer tested under 4,000 or 5,000 volts; the insulation in megohms is read by a special instrument, which measures the effective resistance under an alternating current. As iron cases cannot be used, as they would be magnetised by the transformer, and as any metal would have Foucault currents generated in it, stoneware jars are used for cases. These have lids bolted down, with holes for the leads as shown in the illustration.

TELEPHONIC CHANGES.

Says the *Edinburgh Evening Despatch* in a leading article: "In view of the complications in telephonic politics which are approaching with the expiry of the patents, the resignation of Mr. A. R. Bennett, general manager of the National Telephone Company, is not without significance. Divergence of views between Mr. Bennett and the board of the amalgamated company is stated to be the cause. Such a divergence is not surprising, since the Scottish telephonic system, owing chiefly to Mr. Bennett's technical skill and energetic management, has long been recognised as vastly superior in every respect to any south of the Tweed, while the London system, which is the chief achievement of the gentlemen who now sway the sceptre of the National Company, is a byword and reproach, and a subject for mirth to all but its unfortunate subscribers. Since the Government have definitely decided that telephonic development shall be left to private enterprise—a determination which we feel sure will, in the not distant future, prove a serious and costly mistake—the withdrawal of an engineer of Mr. Bennett's ability and experience is a matter for sincere regret in this part of the country. In the face of great difficulties, he has practically created the Scottish telephonic system, overspreading the land with a network of lines which, in course of time, threatens to rival that of the Post Office, and connecting the leading commercial and industrial communities in such a way as to immensely increase the facilities for carrying on business. Only those who have had experience of the change are capable of appreciating the advantages thus conferred on the country. With such a man at the head of the Scottish system, we should at least have been assured that the progress of the past few years would be maintained. It is not alone on this account that Mr. Bennett's prospective departure from Edinburgh will prove a loss. Scotland is notoriously, and, contrary to her traditions, lagging sadly in the rear in utilising the new force. Electricity, in its manifold applications, is strangely disregarded among us. While the great cities of the barbarous East are being illuminated by its agency, our town councils refuse either to allow a single arc lamp to be introduced into our streets, or to permit others to do it. Mr. Bennett has laboured more than anyone else to expose our national shortcomings in this respect. To this we owe his conception of the present exhibition, which, it may be hoped, will realise his object, and serve to some extent to dispel the general ignorance and apathy with which electric science has come to be regarded among us. Many of the leading features of the exhibition are also due to the initiative and the indomitable zeal of Mr. Bennett. Indeed, it would be difficult to exaggerate the value of his services to the enterprise. It is especially unfortunate, too, that his counsel will not be readily available in connection with the coming problem of street traction in Edinburgh and Glasgow which will soon have to be decided. In this department of electric science few experts are better qualified to speak with authority and knowledge."

UTILISING WATER POWER.

A large project for utilising water power for electric lighting and transmission of power is under active consideration at Kansas City, U.S. A recent local account says: "New facts regarding the plans of the Interstate Water and Electric Power Company, of Kansas City, Mo., have come to the surface, and they reveal that the importance contained in the successful carrying out of the huge project is a matter of deep interest to the citizens of every city and town within a radius of 25 miles of Muncie, Can., the seat of the company's operations. All parties in interest are very reticent about giving out news, saying that the matter has not developed sufficiently for publicity in detail; but from authoritative sources it has been learned that New York agents of New York capitalists are in the city and are verifying the reports sent east by the local organisations. A large force of surveyors and engineers, brought directly from New York City, is at work at the proposed site of the huge dam across the Kaw, and are making practical tests and estimates of everything involved in the gigantic undertaking. Should these observations and tests tally with the plans and written statements sent east by the local company, the money will be forthcoming at once, and the stupendous power scheme will be carried out. The fact that the eastern arrangements have not been fully completed is the main reason for withholding the details of the plans and purposes from the public. Among the many huge projects of the company is that of furnishing the cities and towns within a radius of 25 miles with electric lighting and power. In order to get at once established in this line, it is proposed to buy out the franchises and plants of the Kansas City Electric Light Company, and the Consolidated Electric Light and Power Company, of Kansas City. To purchase the former plant at least 500,000dols. is required, and from 250,000dols. to 350,000dols. for the Kansas City plant. This purchase will give the company the lighting of both cities for a number of years, and the cheapness of power will give it full sway in the furnishing of private lighting. The company is capitalised at 1,000,000dols., but this amount will be doubled before the various schemes are carried out. The estimated cost of the dam across the Kaw river is 80,000dols., and the power buildings, apparatus, and plant generally will cost not less than 250,000dols. Many miles of wire will necessarily have to be laid, and to embrace the manufacturing branch of the scheme the water-power apparatus will involve the expenditure of a large amount of capital. The eastern capitalists who have practically entered into the scheme have, it is understood, interested a number of large eastern manufacturing concerns in the subject of cheap power, and if the dam is constructed will offer inducements to them to transfer their plants there. This will be done under the lease plan, the Power Company agreeing to furnish power at a certain cost for a period of years to be agreed upon, and in addition to this the Power Company will,

in many instances, give sites to the enterprises. This latter was one of the main reasons for the purchase of 273 acres of land at the point near Muncie. The same parties that have control of the local end of the company are interested largely in the smelters at Muncie, Turner, and Lovelace, and will see that these institutions are properly engrafted to the power circuit. The plans for damming the Kaw are in the hands of a local engineer. The construction is to be of stone all through, and will be built in such a manner as to sustain the highest water pressure. A large force of workmen will necessarily be used during the construction period, and at least 300 men will be employed when the work is in full operation. The report of the engineers sent out by the eastern men will be ready in a short time. It is definitely known that so far their tests have gone to show the practicability of the undertaking.

THE BRITISH ASSOCIATION AT LEEDS.

The sixtieth meeting of the British Association for the Advancement of Science was inaugurated at Leeds on Wednesday night, when Sir Frederick A. Abel, C.B., F.R.S., the president for the year, delivered his introductory address to a large and brilliant company in the Leeds Coliseum. The chair was taken by the retiring president, Prof. Flower, who introduced the president-elect, alluding to his special subject of explosives, amusingly deprecating any idea of hostility to the race, and saying that if, unhappily, there arose a necessity for destroying our fellow-creatures, Sir Frederick Abel merely wished it to be done in as scientific a manner as possible. As a set-off against what he had done in that direction, he had also taken a great part in that endeavour which had been made of late years to track out the causes and diminish the frequency of those appalling accidents which rendered the life of the miner one of such anxiety and such risk.

Prof. Flower then vacated the chair, which was taken by Sir Frederick Abel amid the applause of the meeting.

PRESIDENTIAL ADDRESS BY SIR FREDK. AUGUSTUS ABEL, C.B., D.C.L., D.Sc., F.R.S., &c.

Many who had the pleasure of listening last year, at Newcastle, to the interesting and instructive address of the president, to whom I am a most unworthy successor, could not fail, both by the chief subject of his discourse and by the circumstance of the official position which he occupies with so much benefit to science and the public, to have their thoughts directed to the illustrious naturalist whose philosophical address delighted the members of the association and the people of Leeds 32 years ago.

More than one-half the period of existence of this association has passed since Richard Owen presided over its meeting in this town. Alas! what gaps have been created in the ranks of those who then were prominent for activity in advancing its work: the then general secretary, Sir Edward Sabine; the all-popular assistant general secretary, John Phillips; the treasurer, John Taylor, now live with us only through their works and the enduring esteem which they inspired. But very few of those who held other prominent positions at that meeting have survived to see the association reassemble in this town. Whewell, Herschel, Hopkins, the elder Brodie, Murchison, William Fairbairn, all presidents of sections in 1858, have long since been removed from among us; and the then president of Section F, Edward Baines, a much-honoured and highly-talented son of the "Franklin of Leeds," whom we had hoped to count among those vice-presidents representing the city on this occasion, has recently passed away, in his ninetieth year, after a most honourable and useful career, during which he especially distinguished himself by his successful exertions in the advancement of the great educational movements of his time.

The illustrious president of our last meeting here, concerning whose health the gravest apprehensions were not long since entertained, is happily still preserved to us; still intellectually bright at the ripe age of 86, and still, with the keen pleasure of his early life, following the progress of those branches of scientific research which have constituted the favourite occupations and the arena of many intellectual triumphs of a long career of ardent and successful devotion to the advancement of science.

To not a few of those who have flocked to Leeds to attend the annual gathering of this association, our present meeting-place is doubtless known chiefly by its proud position as one of the most thriving manufacturing towns of the United Kingdom; of ancient renown, especially in connection with one of the chief industries identified with Great Britain in years past. But this good town of Leeds, whose cloth market was described by Daniel Defoe, 160 odd years ago, as "a prodigy of its kind, and not to be equalled in the world," and whose present position in connection with divers of our great industries would have equally excited the enthusiasm of that graphic writer, is famous for other things than its prominent association with manufactures and commerce.

Not many of our great industrial centres can boast of so goodly an array upon the scroll of their past history of names of men eminent in the sciences, the arts and manufactures, in divinity and letters, and in heroic achievements, such as are identified with Leeds and its immediate vicinity: Thomas, Lord Fairfax, one of the most prominent heroes of the Commonwealth; Smeaton, an intellectual giant among engineers; William Hirst and John Marshall, illustrious examples of the men who by their genius, energy, and perseverance placed Great Britain upon the pinnacle of industrial and commercial greatness which she so long occupied unassailed; Richard Bentley, the eminent classic and divine; John Nicholson, the Airedale poet; John Fowler and Peter Fairbairn, worthy followers in the footsteps of Smeaton; Isaac Milner, weaver and mathematician, afterwards senior wrangler, Smith's prizeman, Jacksonian Professor, President of Queen's College, Vice-Chancellor of Cambridge University, Dean of Carlisle, and a most illustrious Fellow of the Royal Society; Thoresby, antiquarian and topographer; Benjamin Wilson, painter, and industrious contributor to the development of electrical science; William Hey, the eminent surgeon, and friend and counsellor of Priestley; Sadler, political economist and philanthropist; the brothers Sheepshanks: Richard, the astronomer, and John, the accomplished patron of the arts, and munificent contributor to our national art treasures; Edward Baines, whose conspicuous talents and energy developed a small provincial journal into one of the most powerful public organs of the country; his talented sons, of whom not the least conspicuous and highly respected was the late Sir Edward Baines. I might swell this voluminous list by reference to illustrious members of such families as that of Denison, of Beckett, of Lowther, but the men I have referred to fitly illustrate the remarkable array of worthies whose careers have shed lustre upon the town in or near which they were born. Yet that illustration would be altogether incomplete if I failed to speak of one whose career and works alone would suffice to place Leeds in the foremost rank of those English towns which can claim as their own men whose course of life and whose achievements have secured their pre-eminence among our illustrious countrymen. Needless to say that I refer to Joseph Priestley, born within six miles of Leeds, whose name holds rank among the foremost of successful workers in science, who by brilliant powers of experimental investigation rapidly achieved a series of discoveries which helped largely to dispel the shroud of mystery surrounding the art of alchemy, and to lay the foundation of true chemical science. An ardent student of the classics, of Eastern languages, and of divinity, a zealous exponent of theological doctrines which marred his career as divine and instructor, he early displayed conspicuous talents for the cultivation of experimental science, which he pursued with ardour under formidable difficulties. His acquaintance with Franklin probably developed the taste for the study of electric science which led him to labour successfully in this direction; and the publication, in 1767, of his valuable work on "The History and Present State of Electricity, with Original Experiments," secured him a prominent position among the working Fellows of the Royal Society. His connection with Mill Hill Chapel, in 1768, appears to have given rise, accidentally, to his first embracing the experimental pursuit of what formerly was termed pneumatic chemistry, the foundation to which had been laid by Cavendish's memorable contribution, in 1766, to the "Philosophical Transactions," on carbonic acid and hydrogen. Priestley's first publication in pneumatic chemistry, on "Impregnating Water with Fixed Air" (carbonic acid), attracted great attention; it was at once translated into French, and the College of Physicians addressed the Lords of the Treasury thereon, pointing out the advantages which might result from the employment, by men at sea, of water impregnated with carbonic acid gas, as a protective against, or cure for, scurvy.

Six years later Priestley investigated the chemical effects produced on the air by the burning of candles and the respiration of animals, and, having demonstrated that it was thereby diminished in volume and deteriorated, he showed that living plants possessed the power of rendering air, which had been thus deteriorated, once more capable of supporting the combustion of a candle. At about this time Priestley received very advantageous proposals to accompany Captain Cook upon his second expedition to the South Seas; but when about to prepare for his departure he learned from Sir Joseph Banks that objections against his appointment, on account of the great latitude of his religious principles, had been successfully urged by some ecclesiastic member of the Board of Longitude. In 1773 the Royal Society awarded Priestley the Copley Medal for a remarkable paper entitled "Observations on Different Kinds of Air," and in that year he became librarian and literary companion to the Earl of Shelbourne (afterwards Marquis of Lansdowne), and thereby secured special advantages in the pursuit of his scientific researches.

With respect to his departure from Leeds, he expressed himself as having been very happy there "with a liberal, friendly, and harmonious congregation, to whom my services (of which I was not sparing) were very acceptable. Here I had no unreasonable prejudices to contend with, so that I had full scope for every kind of exertion, and I can truly say that I always considered the office of a Christian minister as the most honourable of any upon earth, and in the studies proper to it I always took the greatest pleasure." During the next five years he published as many volumes describing the results of important experiments on air. After investigating the properties of nitric oxide, and applying it to the

analysis of air, Priestley, in 1774, discovered and carefully studied oxygen, which he obtained by the action of heat upon the red oxide of mercury. He was the first to prepare and study sulphurous acid, carbonic oxide, nitrous oxide, hydrochloric acid (*marine acid air*), and the fluoride of silicon, and carried out important researches on the properties of hydrogen, and of other gases previously but little known. His great quickness of perception and power of experiment led him to the achievement of many novel and important results; but one cannot help contrasting his somewhat random search after new discoveries with the close logical reasoning and philosophic spirit which guided and pervaded the remarkable researches of him whose departure from amongst us since the last gathering of this association is so universally deplored—of the great discoverer of the universal law of the conversion of energy, James Prescott Joule. I could not add to the judicious and graceful reference to his work which Sir Henry Roscoe was privileged to make, in the last year of that philosopher's valuable life, when presiding over the recent meeting of the association in the town which gloried in numbering Joule among its citizens; but I may, perhaps, be permitted to express the sanguine hope that the desire of the scientific world to secure the establishment of an international memorial fitly commemorative of his great life work may be realised in the most ample manner.

The wide scope of the admirable discourse delivered by Owen in this town 32 years ago affords an interesting illustration of the delight which men whose best energies are devoted to the cultivation of one particular branch of science take in the results of the labours of their fellow-workers in other departments, and in their achievements in contributing to the general advancement of our knowledge of Nature's laws and of their operations. It is to this bond of intimate union between all workers in pure science that we owe the instructive reviews of the progress made in different departments of science with which we have often been presented at our annual gatherings. On the other hand, those men from time to time selected to fill the distinguished office of president, whose lives have been mainly devoted to the practical utilisation of the results of scientific research, and to the extension in particular directions of the consequent resources of civilisation, seize with keen pleasure the opportunity afforded them of directing attention to the triumphs achieved in the applications to the purposes of daily life of the great scientific truths established by such illustrious labourers in the fields of pure science as Newton, Dalton, Faraday, and Joule. The wide and constantly-extending domain of applied science presents, even to the superficial observer, a continually varied scene; not a year passes but some great prize falls to the lot of one or other of its explorers, and some apparently insignificant vein of treasure, struck upon but a few years back, is rapidly opened out by cunning explorers, until it leads to a mine of vast wealth from which branch out in many directions new sources of power and might.

Among the branches of science in the practical applications of which the greatest strides have been made since the association met at Leeds in 1858 is electricity. That year witnessed the accomplishment of the first great step towards the establishment of electrical communication between Europe and America, by the laying of a telegraph cable connecting Newfoundland with Valencia. Through this cable a message of 31 words was shortly afterwards transmitted in 35 minutes; an achievement which, though exciting great enthusiasm at the time, scarcely afforded promise of the succession of triumphs of ocean telegraphy which have since surpassed the wildest dreams of the pioneers in the realms of applied electricity.

The development of the electric telegraph constitutes a never-failing subject of the liveliest interest. The experiments made by Stephen Gray, in 1727, of transmitting electrical impulses through a wire 700ft. long; by Watson, 20 years afterwards, of transmitting frictional electricity through many thousand feet of wire, supported by a line of poles, on Shooter's Hill, in Kent, and by Franklin, who carried out a similar experiment at Philadelphia, although they were followed by many other interesting and philosophical applications of frictional electricity to the transmission of signals—were not productive of really practical results. The work of Galvani and of Volta was more fruitful of an approach to practical telegraphy in the hands of Sömmering and of Coxe, while the researches of Oersted, of Ampère, of Sturgeon, and of Ohm, and especially the discoveries of volta-electric induction and magneto-electricity by Faraday, paved the way for the development of the electric telegraph as a practical reality by Cooke and Wheatstone in 1837. How remarkable the strides have been in the resources and powers of the telegraphist since that time is demonstrated by a few such facts as these: The first needle instrument of Cooke and Wheatstone transmitted messages at the rate of four words per minute, requiring five wires for that purpose; six messages are now conveyed by one single wire at 10 times that speed, and news is dispatched at the rate of 600 words per minute. Duplex working, which more than doubled the transmitting power of a submarine cable, was soon eclipsed by the application of Edison's quadruplex working, which has in its turn been surpassed by the multiplex system, whereby six messages may be sent independently in either direction on one wire. When last the British Association met in Leeds submarine telegraphy had but just started into existence; 30 years later the accomplished president of the Mechanical Section informed us at our meeting at Bath that 110,000 miles of cable had been laid by British ships, and that a fleet of nearly 40 ships was occupied in various oceans in maintaining existing cables and laying new ones.

The important practical achievements by which most formidable difficulties have been surmounted step by step in the successive attainment of the marvellous results of our day have exerted an influence upon the advancement, not merely of electrical science, but also of science generally and of its applications, fully equal to that which they have exercised upon the development of commerce and of the intercourse between the nations of the earth.

Thus, the laying of the earliest submarine cables, between 1851 and 1855, led Sir W. Thomson, in conference with Sir George Stokes, to work out the theory of signalling in such cables by utilising the mathematical results arrived at by Fourier in his investigation of the propagation of heat-waves. The failure of the first Atlantic cable led to the survey of the bottom of the Atlantic, which was the forerunner of deep-sea explorations, culminating in the work of the "Challenger" Expedition, and opening up new treasures of knowledge scarcely dreamt of when last the British Association met at Leeds. To the difficulties connected with the early attempts at submarine telegraphy, and the determination with which Thomson drove home the lessons learned, we owe the systematic investigations into the causes of the variations in resistance of copper conductors, and the consequent improvements in the metallurgy of copper, which led to the realisation of the high standard of purity of metal essential for the efficient working of telegraphic systems, and also to the extensive utilisation of electricity in the production of pure copper. The rare combination of originality in powers of research and perspicuity in mathematical reasoning, with inventive and constructive genius for which Thomson has so long been pre-eminent, has placed at the disposal of the investigator of electric science, and of the practical electrician, instruments of measurement and record which have been of incalculable value, and which owe their origin to the theoretical conclusions arrived at by him in his researches into the conditions to be fulfilled for the attainment of practical success in the construction and employment of submarine cables. The mirror galvanometer, the quadrant electrometer, the syphon recorder, and the divided-ring electrometer, are illustrations of the valuable outcome of Thomson's labours; the combination of the last-named instrument with sliding resistance coils has rendered possible the accurate subdivision of a potential difference into 10,000 equal parts. The general use of condensers in connection with cable signalling, due to Varley's application of them for signalling through submerged cables with induced short waves, was instrumental in establishing the fact that all electrostatic phenomena are simply the result of starting an electric current of known short duration round a closed circuit. The practical application of the Wheatstone bridge led to numerous important mathematical investigations, and induced Clerk Maxwell to devise a new mode of applying determinants to the solution of the complicated electrical problems connected with networks of conductors. The necessity for the universal recognition of an electrical unit of resistance led to the establishment, in 1860, of the Electrical Standards Committee of the British Association, whose long succession of important annual reports was instrumental in most important developments of theoretical electricity, and, indeed, served to open up the whole science of electrical measurement. Matthiessen's important investigations of the electrical behaviour of metals and their alloys, and the preparation and properties of pure iron, were the outcome of the commercial demand for a practically useful standard of electrical resistance, while Latimer Clark's practical standard of E.M.F., the mercurous sulphate cell, became invaluable to the worker in pure electrical research. The unit of resistance established by the British Association Committee received, in 1866, most important scientific application at the hands of Joule, who, by measuring the rate of development of heat in a wire of known resistance by the passage of a known current, obtained a new value of the mechanical equivalent of heat. This value differed by about 1·3 per cent. from the most accurate results arrived at by his experiments on mechanical friction, a difference which eventually proved to be exactly the error in the British Association unit of resistance; so that the true value of the unit of resistance, or ohm, was determined by Joule 15 years before this result was achieved by electricians. Clerk Maxwell's remarkable electromagnetic theory of light was put to the test, through the aid of the British Association unit of resistance, by Thomson, in determining the ratio of electromagnetic unit to the electrostatic unit of quantity. Many other most interesting illustrations might be given of the invaluable aid afforded to purely scientific research by the practical results of the development of electrical science, and of the constant co-operation between the science student and the practical worker. No one could more fitly, than the late Sir William Siemens, have maintained, as he did, in his admirable address at our meeting in Southampton, in 1882, that we owe most of the rapid progress of recent times to the man of science who partly devotes his energies to the solution of practical problems, and to the practitioner who finds relaxation in the prosecution of purely scientific enquiries. Most assuredly, both these classes of the world's benefactors may with equal right lay claim to rank the name of Siemens among those whom they count most illustrious!

In that highly interesting and valuable address, delivered little more than a year before his sudden untimely removal from among us, the numerous important subjects discussed by him included not a few which he had made peculiarly his own in the wide range embraced by his enviable power of combining scientific research with practical work. Prominent among these were the applications of electric energy to lighting and heating purposes, and to the transmission of power, to the future development of which his personal labours very greatly contributed.

Siemens referred to the passing of the first Electric Lighting Bill, in the year of his presidency, as being designed to facilitate the establishment of electric installations in towns; but the anxiety of the Government of that day to protect the interests of the

and in America. Comparatively little has been accomplished in this direction in England, but it is very interesting to note on the present occasion that the first successful practical application of electricity in this country to pumping and underground haulage work was made in 1887 in this neighbourhood, at the St. John's Colliery, at Normanton, where an extensive installation, carried out by Mr. Immisch, so well known in connection with electric launches, is furnishing very satisfactory results in point of economy and efficiency. The gigantic installations existing for the same purposes in Nevada and California afford remarkable illustrations of the work to be accomplished in the future by electrically-transmitted energy.

Among the many subjects of importance studied by Joule with the originality and thoroughness characteristic of his work was the application of voltaic electricity to the welding and fusion of metals. Thirty-four years ago he published a most suggestive paper on the subject, in which, after dealing with the difficulties attending the operation of welding, and of the interference of films of oxide, formed upon the highly-heated iron surfaces, with the production of perfect welds either under the hammer or by the methods of pressure (of which he then predicted the application to large masses of forged iron), he refers to the possibility of applying the calorific agency of the electric current to the welding of metals, and describes an operation witnessed by him in the laboratory of his fellow-labourer, Thomson, of fusing together a bundle of iron wires by transmitting through them, when embedded in charcoal, a powerful voltaic current. Joule afterwards succeeded in fusing together a number of iron wires with the current of a Daniell battery, and of welding together wires of brass and steel, platinum and iron, etc. In discussing the question of the amount of zinc consumed in a battery for raising a given amount of iron to the temperature of fusion, he points out that the same object would probably be more economically attained by the use of a magneto-electric machine, which would allow the heat to be provided by the expenditure of mechanical force, developed in the first instance by the expenditure of heat; and he indicates the possibility of arranging machinery to produce electric currents which shall evolve one-tenth of the total heat due to the combustion of the coal used, so that 5,000 grains of coal applied through that agency would suffice for the fusion of 1lb. of iron. The successful practical realisation of Joule's predictions in regard to the application of electric currents thus developed to the welding of iron and steel, and to analogous operations through the agency of the efficient machines devised by Prof. Elihu Thomson, was demonstrated to the members of the association by Prof. Ayrton at Bath two years ago, and was shown upon a larger scale to visitors at the Paris Exhibition last year, and recently to highly-interested audiences in London by our late president, Sir Frederick Bramwell. The latter demonstrated that the production of iron welds by means of the Thomson machines was accomplished nearly twice as rapidly as by expert craftsmen; the perfection of the welds being proved by the fact that the strength of bars broken by tensile strains at the welds themselves was about 92 per cent. of the strength of the solid metal. At the Crewe Works Mr. Webb is successfully applying one of these machines to a variety of welding work. The rapidity with which masses of metal of various dimensions are raised in those machines to welding heat is quite under control; the heat is applied without the advent of any impurities, as from fuel, and the speed of execution of the welding operation reduces to a minimum the time during which the heated surfaces are liable to oxidise. With such practical advantages as these, this system of electric welding bids fair to receive many useful applications.

Another very simple system of electric welding, especially applicable to thin iron and steel sheets, hoops, etc., has been contemporaneously elaborated in Russia by Dr. Bernados, and is already being extensively used. The required heat at the surfaces to be welded is developed by connecting the metal with the negative pole of the dynamo machine or of a battery of accumulators, the circuit being completed by applying a carbon electrode to the parts to be heated. The reducing power of the carbon is said to preserve the heated metal surfaces from oxidation during the very brief period of heating. This mode of operation appears to have been practised upon a small scale some years ago by Sir William Siemens, to whom we also owe the first attempt to practically apply electric energy to the smelting of metals.

In his address in 1882 he referred to some results attained with his small electrical furnace, and pointed out that although electric energy could obviously not compete economically with the direct combustion of fuel for the production of ordinary degrees of heat, the electric furnace would probably receive advantageous application for the attainment of temperatures exceeding the limits (about 1,800deg. C.) beyond which combustion was known to proceed very sluggishly. This prediction appears to have been already realised through the important labours of Messrs. Cowles, who some years ago attacked the subject of the application of electricity to the achievement of metallurgic operations with the characteristic vigour and fertility of resource of our Transatlantic brethren. After very promising preliminary experiments, they succeeded in 1885, at Cleveland, Ohio, in maturing a method of operation for the production of aluminium-bronze, ferro-aluminium, and silicium-bronze, with results so satisfactory as to lead to the erection of extensive works at Lockport, N.Y., where three dynamo machines, each supplying a current of about 3,000 amperes, are worked by water power through the agency of turbines, each of 500 h.p., 18 electric furnaces being now in operation for the production of aluminium alloys. These achievements have led to the establishment of similar works in North Staffordshire, where a gigantic dynamo machine has been erected, furnishing a current of 5,000 amperes, with an E.M.F. of 50 to 60 volts. The arrangement of the electrodes in the furnaces, the preparation of the furnace charges (consisting of mixtures of aluminium ore with charcoal and with the particular granulated metal with which the aluminium is to become alloyed at the moment of its elimination from the ore), the appliances for securing safety in dealing with the current from the huge dynamo machine, and many other details connected with this new system of metallurgic work, possess great interest. Various valuable copper and aluminium alloys are now produced by alloying copper itself with definite proportions of the copper alloy, very rich in aluminium, which is the product of the electric furnace. The rapid production in large quantities of ferro-aluminium—which presents the aluminium in a form suitable for addition in definite proportions to fluid cast iron and steel—is another useful outcome of the practical development of the electric furnace by Messrs. Cowles.

The electric process of producing aluminium alloys has, however, to compete commercially with their manufacture by adding to metals or alloys pure aluminium produced by processes based upon the methods originally indicated by Oersted in 1824, successfully carried out by Wöhler three years later, and developed into a practical process by H. St. Claire Deville in 1854—namely, by eliminating aluminium from the double chloride of sodium and aluminium in the presence of a fluoride, through the agency of sodium. An analogous process, indicated in the first instance by H. Rose—namely, the corresponding action of sodium upon the mineral cryolite, a double fluoride of aluminium and sodium—has also been recently developed at Newcastle, where the first of these methods was applied upon a somewhat considerable scale, in 1860, by Sir Lowthian Bell, but did not then become a commercial success, mainly owing to the costliness of the requisite sodium. As the cost of this metal chiefly determines the price of the aluminium, technical chemists have devoted their best energies to the perfection and simplification of methods for its production, and the success which has culminated in the admirable Castner process constitutes one of the most interesting of recent illustrations of the progress made in technical chemistry, consequent upon the happy blending of chemical with mechanical science, through the labours of the chemical engineer.

Those who, like myself, remember how, between 40 and 50 years ago, a few grains of sodium and potassium were treasured up by the chemist, and used with parsimonious care in an occasional lecture experiment, cannot tire of feasting their eyes on the stores of sodium ingots to be seen at Oldbury as the results of a rapidly and dexterously executed series of chemical and mechanical operations.

The reduction which has been effected in the cost of production of aluminium through this and other processes, and which has certainly not yet reached its limit, can scarcely fail to lead to applications of the valuable chemical and physical properties of this metal so widespread as to render it as indispensable in industries and the purposes of daily life as those well-known metals which may be termed domestic, even although, and, indeed, for the very reason that, its association with many of these, in small proportion only, may suffice to enhance their valuable properties or to impart to them novel characteristics.

The Swedish metallurgist, Wittenström, appears to have been the first to observe that the addition of small quantities of aluminium to fused steel and malleable iron had the effect of rendering them more fluid, and, by thus facilitating the escape of entangled gases, of ensuring the production of sound castings without any prejudicial effect upon the quality of the metal. The excellence of the so-called Mitis castings, produced in this way, appears thoroughly established, and the results of recent important experiments seem to be opening up a field for the extensive employment of aluminium in this direction, provided its cost becomes sufficiently reduced. The valuable scientific and practical experiments of W. J. Keep, James Riley, R. Hadfield, Stead, and other talented workers in this country and the United States, are rapidly extending our knowledge in regard to the real effects of aluminium upon steel and their causes. Thus, it appears to be already established that the modifications in some of the physical properties of steel resulting from the addition of that metal, are not merely ascribable to its actual entrance into the composition of the steel, but are due, in part, to the deoxidation by aluminium of some proportion of iron oxide which exists distributed through the metal, and prejudicially affects its fluidity when melted. In the latter respect, therefore, the influence exerted by aluminium, when introduced in small proportions into malleable iron and steel, appears to be quite analogous to that of phosphorus, silicium, or lead when these are added in small proportions to copper and certain of its alloys, the deoxidation of which, through the agency of those substances, results in the production of sound castings of increased strength and uniformity. It is only when present in small proportion in the finished steel, that aluminium increases the breaking strain and elastic limit of the product.

The influence of aluminium, when used in small proportion, upon the properties of grey and white cast iron, is also of considerable interest, especially its effect in promoting the production of sound castings, and of modifying the character of white iron in a similar manner to silicium, causing the carbon to be separated in the graphitic form; with this difference—that the carbon appears to be held in solution until the moment of setting of the liquid metal, when it is instantaneously liberated, with the result that the structure of the cast metal and distribution of the graphite are perfectly uniform throughout.

The probable beneficial connection of aluminium with the industries of iron and steel naturally directs attention to the great practical importance, in the same direction, which has

already been acquired, and promises to be in increasing measure attained, by certain other metals which, for long periods succeeding their discovery, have either been only of purely scientific interest and importance, or have acquired practical value in regard to their positions in a few directions quite unconnected with metallurgy. Thus, great interest attaches to the influence of the metals manganese, chromium, and tungsten upon the physical properties of steel and iron.

The name of Mushet is most prominently associated with the history of manganese in its relations to iron and steel. Half a century ago David Mushet carried out very instructive experiments on the influence exerted upon the properties of steel by the presence of manganese; and to Robert Mushet we owe the invaluable experiments leading to his suggestion to use manganese in the production of steel by the Bessemer process, which at once smoothed the path to the marvellously rapid and extensive development of the applications of steel produced by that classic method, and subsequently by the open-hearth or Siemens-Martin process—a development which has recently received its crowning illustration in the completion of one of the grandest of existing triumphs of engineering science and constructive skill—the Forth Bridge.

Robert Hadfield has recently contributed importantly to our knowledge of the relations of manganese to iron. His systematic study of the subject has revealed some very remarkable variations in the physical properties of so-called manganese steel, according to the proportions of manganese which it contains. Thus, while the existence in steel of proportions ranging from 0·1 up to about 2·75 per cent. improves its strength and malleability, it becomes brittle if that limit is exceeded, the extreme of brittleness being obtained with between 4 and 5 per cent. of manganese. If, however, the percentage is increased to not less than 7 and up to 20, alloys of remarkable strength and toughness are obtained. Castings of high manganese steel, such as wheel tyres, combine remarkable hardness with toughness. Even if the proportion of manganese is as high as 20 per cent. in a steel containing 2 per cent. of carbon, it can be forged, whereas it is very difficult to forge a steel of ordinary composition containing as much as 2·75 per cent. of carbon.

Another remarkable peculiarity of the high manganese steel is its behaviour when quenched in water. Instead of the heated metal being hardened and rendered brittle by the sudden cooling, like carbon steel, its tensile strength and its toughness are increased, so that water-quenching is really a toughening process, as applied to the manganese alloy, and an interesting feature connected with this is that the colder the bath into which the highly-heated metal is plunged the tougher is the product. The curious effect of manganese in reducing, and even destroying, the magnetic properties of iron was already noticed by Rinman nearly 120 years ago; one result of Hadfield's important labours has been to place in the hands of such eminent physicists as Thomson, John Hopkinson, and Reinold, materials for the attainment of most interesting information respecting the electrical and other physical characteristics of manganese steel. Hopkinson, from experiments with a sample of steel containing 12 per cent. of manganese, estimated that not more than nine out of the 86 per cent. of the iron composing the mass was magnetic, and he considered that the manganese enters into that which must, for magnetic purposes, be regarded as the molecule of iron, completely changing its properties, a fact which must have great significance in any theory regarding the nature of magnetisation. The great hardness of manganese steel, and the consequent difficulty of dealing with it by means of cutting tools, constitute at present the chief impediments to its technical applications in many directions; but where great accuracy of dimensions is not required, and where great strength is an essential, it is already put to valuable uses.

The importance of manganese in connection with the metallurgy of iron and steel is in a fair way of finding its rival in that of the metal chromium, the employment of which, as an alloy with steel, was first made the subject of experiment in 1821 by Berthier, who was led by the important experiments of Faraday and Stoddart, then just published, to endeavour to alloy chromium with steel, and obtained good results by fusing steel together with a rich alloy of chromium and iron, so as to introduce about 15 per cent. of the former into the metal. Further small experiments were made the year following by Faraday and Stoddart in the same direction; but chrome steel appears to have been first produced commercially at Brooklyn, N.Y., 16 years ago. Ten years later its manufacture had become developed in France, and the varieties of chrome steel produced in the Loire district now receive important and continually-extending applications on account of their combining comparative hardness with high tenacity, and only little loss in ductility, and of their acquiring great closeness of structure when tempered.

The influence of chromium upon the character of steel differs in several marked respects from that exercised by manganese. Thus chrome steels weld badly or not at all, whereas manganese steels weld very readily, and work under the hammer better than ordinary carbon steel. Again, the remarkable influence of manganese upon the magnetic properties of steel and iron is not shared by chromium. Chrome steel has for some time been a formidable rival of the very highest qualities of carbon steel produced for cutting tools, and of the valuable tungsten steel which we owe to Robert Mushet. The great hardness, high tenacity, and exceeding closeness of structure possessed by suitably-tempered steel containing not more than from 1 to 1·5 per cent. of chromium, and from 0·8 to 1 per cent. of carbon, renders this material invaluable for war purposes: cast projectiles, when suitably tempered, have penetrated compound steel and iron plates over 9in. in thickness, such as are used upon armoured ships of war, without even sustaining any important change of form. The proper tempering of these projectiles necessitates their being produced hollow; their cavities or chambers are only of small capacity, but the charge of violent explosive which they can contain, and which can be set into action without the intervention of fuse or denotating appliance, suffices to tear these formidable punching tools into fragments as they force their way irresistibly through the armoured side of a ship, and to violently project those fragments in all directions, with fearfully destructive effects. The employment of chromium as a constituent of steel plates used for the protection of ships of war is already being entered upon, and the influence exerted by the presence of that metal in small quantities in steel employed in the construction of guns is also at present a subject of investigation. At Crewe, Mr. F. Webb has for some past used chromium, with considerable advantage, in the production of high quality steels for railway requirements.

The practical results attained by the introduction of copper and of nickel as components of steel have also recently attracted much attention. At the celebrated French steel works of M. Schneider, at Creuzot, the addition of a small percentage of copper to steel used for armour-plates and projectiles is practised, with the object of imparting hardness to the metal without prejudice to its toughness. James Riley has found that the presence of aluminium in very small quantities facilitates the union of steel with a small proportion of copper, and that the latter increases the strength, but does not improve the working qualities of steel. With nickel, Riley has obtained products analogous in many important respects to manganese steel; the remarkable differences in the physical properties of the manganese alloys, according to their richness in that metal, are also shared by the nickel alloys, some of these being possessed of very valuable properties. Thus, it has been shown by Riley that a particular variety of nickel steel presents to the engineer the means of nearly doubling boiler pressures without increasing weight or dimensions. He has, moreover, found the co-existence of manganese in small quantity with nickel in the alloy to contribute importantly to the development of valuable physical properties.

The careful study of the alloys of aluminium, chromium, manganese, tungsten, copper, and nickel, with iron and with steel, so far as it has been carried, with especial reference to the influence which they respectively exercise upon the salient physical properties of those materials, even when present in them in only very small proportions, has demonstrated the importance of a more searching or complete application of chemical analysis than hitherto practised to the determination of the composition of the varieties of steel which practical experience has shown to be peculiarly adapted to particular uses. It appears, indeed, not improbable that certain properties of these, which have been ascribed to slight variations in the proportion or the condition of the constituent carbon, or in the amounts of silicium, phosphorus, and manganese which they contain, may sometimes have been due to the presence in minute quantities of one or other of such metals as those named, and to the effects which they produce, either directly or indirectly, by modifying or counteracting the effects of the normal constituents of steel. The important part now played by manganese in steel manufacture is an illustration of the comparatively recent results of research, and of practical work based on research, in these directions, and the effects of the presence in steel of only very small quantities of some of the other metals named are already, as I have pointed out, being similarly understood and utilised.

(To be continued.)

COMPANIES' REPORTS.

BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED.

DIRECTORS.

The Right Hon. Lord Thurlow, F.R.S., chairman.
J. S. Sellon, Esq. (of Messrs. Johnson, Matthey, and Co.), vice-chairman.
J. B. Braithwaite, Esq., jun. (of Messrs. Foster and Braithwaite).
His Grace the Duke of Marlborough.
Aymor H. Sanderson, Esq. (late Director Falcon Engine and Car Works, Limited).
Colonel Frederick George Steuart.
B. H. Van Tromp, Esq. (late Chairman Australasian Electric Light and Power Co., Limited).
Edward Woods, Esq. (Past President Institution of Civil Engineers).

MANAGER AND SECRETARY.

E. Garcke.

First annual report to be presented to the shareholders at the general meeting to be held at Cannon-street Hotel, E.C., on the 8th September, 1890, at 12 o'clock.

The Directors beg to submit the balance-sheet and profit and loss account, made up to 30th June last. The Company was registered on the 10th August, 1889, and the business of the Anglo-American Brush Electric Light Corporation, Limited, was taken over as from the 1st August, 1889, and that of the Falcon Engine and Car Works, Limited, as from the 14th June, 1889, and the accounts made up to the 30th June last are for the periods embraced by these dates. The arrangements for carrying on the business of the Australasian Electric Light and Power Company, Limited, were not completed until much later, and the accom-

panying accounts do not include any return of business effected by the Australasian branch. The profit and loss account shows a gross profit of £36,698. 16s., and after deducting all standing charges, maintenance of plant and buildings, and interest on debentures, there remains a balance of £14,235. 6s. 1d. It is proposed to apply £625 to reduction of preliminary expenses, £500 to reduction of provisional orders account, and £3,000 to reduction of property, patents, and goodwill account to meet depreciation under these heads. The net balance of £10,426. 19s. 3d. is available for dividends. An interim dividend, absorbing £3,808. 6s. 10d., has already been paid upon the preference shares for the six months from 10th August to 10th February last, and it is proposed to apply £3,505. 4s. 6d. to the payment of a further dividend upon these shares, making up the full preferential dividend at the rate of 6 per cent. per annum from the date of registration of Company to 30th June, 1890. The Directors recommend that the balance of £2,796. 14s. 9d. be carried forward to next account. The temporary interruption to business caused by the amalgamations with other companies and extensions of works has to some extent adversely affected the profit and loss account, and as several months had necessarily to elapse before the new works at Loughborough could be completed, the advantages of the lower cost of production at the country works were not obtained in regard to a large proportion of the orders executed. In view of all these circumstances, the Directors consider the result of the year's working as encouraging. The Falcon Works at Loughborough have been considerably enlarged during the year at an expenditure of about £20,000, and the extension of these works enables the Company to manufacture at a materially reduced cost engines, boilers, cars, and electrical machinery of practically every description and size. The Directors are of opinion that this money has been well spent, and they anticipate good results in the future from the erection of these works. It affords the Directors much satisfaction to state that the Bill confirming the provisional order for lighting the central division of the City of London has been passed by Parliament. The agreement with the Commissioners of Sewers of the City of London provides that the work for the purpose of public lighting shall be commenced within nine months from the 21st May last, and the Directors are making the necessary preparations for giving effect to this condition. The Company has also obtained a provisional order for Bournemouth, where a central electric light station has already been erected, which promises to yield very satisfactory returns. The Directors have applied to the Board of Trade for provisional orders for several other towns in the United Kingdom where the Company has interests to protect. The Austro-Hungarian businesses have developed in a satisfactory manner, and the Vienna factory shows improving results both as to volume of trade and as to net profit. The necessity for providing additional factory accommodation in Vienna has now arisen, and the Directors are concluding negotiations for the acquisition of some freehold land and buildings adjoining the present works. They have also under consideration proposals for a rearrangement of the Company's interests in the Vienna business. The Directors have, with the assistance of Captain Rowan, late general manager of the Australasian Company, fully examined into the character of the business acquired from that company, and have made arrangements for the proper development of the Company's valuable patents and organisation in the colonies. Messrs. Cooper Brothers and Co., the auditors, offer themselves for re-election.

BALANCE-SHEET, 30TH JUNE, 1890.

Dr.	£	s.	d.	£	s.	d.
To authorised capital	750,000	0	0			
To capital issued—viz.:						
68,996 6 per cent. preference shares of £2 each	137,992	0	0			
76,978 ordinary shares of £3 each	230,934	0	0			
	368,926	0	0			
Less calls in arrear	256	10	0			
				368,669	10	0
To 6 per cent. mortgage debentures				75,000	0	0
To creditors—						
Loans and sundry creditors	67,358	14	1			
Bills payable	1,777	4	4			
				69,135	18	5
To balance of profit and loss account	14,235	6	1			
Less interim dividend paid on preference shares	3,808	6	10			
				10,426	19	3
				£523,232	7	8

Cr.	£	s.	d.	£	s.	d.
By property, patents, and goodwill— For value of plant, freehold and leasehold land and buildings at Loughborough, in Leicestershire, at Lambeth, Borough-road, and Hammersmith in London, at Edinburgh, Cardiff, Glasgow, Manchester and Bournemouth, and of central station at Temesvar, of business of Kremenzky, Mayer and Co., Vienna, and of English, foreign, and colonial Brush, Edison and other patents, and of goodwill of the Anglo-American Brush Electric Light Corporation, the Falcon Engine and Car Works, Limited, and the Australasian Electric Light and Power Company. (See report).				297,400	8	10
Brought forward				297,400	8	10
By stock— Goods in hand in process of manufacture and materials at London, Loughborough, and other places				84,468	6	6
By debtors—						
Sundry accounts (after provision for doubtful debts)	80,495	17	3			
Bills receivable	5,277	15	3			
				85,773	12	6
By cash at bankers on deposit and in hand	29,649	2	0			
Deposit under City contract	1,000	0	0			
				30,649	2	0
By shares and debentures in other companies (at cost values)				11,534	0	0
By provisional orders account— Amount spent on provisional orders secured and applied for				1,540	6	1
By preliminary expenses				1,886	15	8
By liquidators' balances and suspense accounts				9,979	16	1
				£523,232	7	8

APPROPRIATION ACCOUNT.

Dr.	£	s.	d.
To further dividend on preference shares	3,505	4	6
,, Reduction of property account	3,000	0	0
,, do. of preliminary expenses	625	0	0
,, do. of provisional orders account	500	0	0
,, Balance carried forward	2,796	14	9
	£10,426	19	3

Cr.	£	s.	d.
By balance	10,426	19	3
	£10,426	19	3

PROFIT AND LOSS ACCOUNT FROM DATE OF REGISTRATION OF COMPANY (10TH AUGUST, 1889) TO 30TH JUNE, 1890.

Dr.	£	s.	d.	£	s.	d.
To general charges—viz.:						
Directors' fees	1,750	0	0			
Auditors' fees	52	10	0			
Salaries	8,088	6	7			
Law charges	438	7	0			
Insurance	857	0	2			
Postage, stationery, and printing	1,368	0	4			
Travelling, carriage, and freight	828	10	1			
Advertising agency and sundries	2,620	5	8			
				16,002	19	10
To maintenance of plant and buildings				2,559	12	5
,, do. of patents				738	12	3
,, Interest on debentures to 30th June, 1890				3,162	5	5
,, Balance, being net profit				14,235	6	1
				£36,698	16	0

Cr.	£	s.	d.
By gross profit	36,698	16	0
	£36,698	16	0

NEW COMPANIES REGISTERED.

Lamp Manufacturing Company, Limited.—This Company was registered last Tuesday, with a capital of £16,000, divided into 1,000 preference shares of £10 each, and 3,000 ordinary and 3,000 deferred shares of £1 each, to adopt an agreement with the Ridsdale Railway Lamp and Lighting Company, Limited, and its liquidator, Mr. Edward Cecil Moore, to manufacture lamps of all kinds, and apparatus for the consumption and supply of gas, oil, and electricity; to carry on business as mechanical, gas, and electrical engineers; and to produce and supply gas, oil, electricity, or electrical currents or force, for light, heat, or motive power.

Sheffield Telephone Exchange and Electric Light Company, Limited.—Registered by J. B. Roberts, 12, Coleman-street, E.C., with a capital of £100,000 in £10 shares. Object: to acquire the undertaking of the Sheffield Telephone Exchange and Electric Light Company, Limited (incorporated September 11, 1888), and to carry on in the United Kingdom or abroad all or any of the businesses of forming, establishing, and conducting telephonic and electric exchanges or centres, and of dealers in and leasing or letting of telephones and telephonic apparatus and wires. The first subscribers are:

	Shares.
J. Tasker, Crookes House, Sheffield	1
G. Senior, Mushroom Hall, Sheffield	1
G. Franklin, Claremont, Sheffield	1
W. Johnson, Albany-road, Sheffield	1
T. G. Shuttleworth, Sharrow Mount, Sheffield	1
R. C. Tasker, 23, Tapton-villas, Sheffield	1
W. Tasker, 1, Parkes-road, Sheffield	1

There shall not be less than three nor more than six Directors. The first are John Tasker (chairman), Joseph Gamble, George

Senior, George Franklin, and William Tasker. Qualification, 20 shares. Remuneration, £300, divisible.

Western Railway Company of Mexico, Limited.—Registered by Bircham and Co., 50, Old Broad-street, E.C., with a capital of £231,000 in £10 shares. Object: to construct, equip, and work railways and tramways, and to carry on the business of railway and tramway proprietors and carriers in Mexico and elsewhere, and further the purchase of the railway between the Port of Altata and the City of Culiachan, Mexico, and all other the franchises, concessions, and rights, lands, rights of way, telegraphs and telephones, with their rolling stock, plant, and accessories of every description. The first subscribers are:

	Shares.
W. J. Longhurst, 20, Abchurch-lane	1
T. S. H. Drake, 1, St. James's-street, S.W.	1
L. Du Cane, 25, Park-crescent, W.	1
T. O. Chapman, The Chestwich, Finchley	1
M. Eberstah, 23, Bentinck-st., Manchester-square, W.	1
L. G. Mortimer, 1, Gresham House	1
T. Carmichael, 72, Radcliffe-square, S.W.	1

There shall not be less than three nor more than 11 Directors. Qualification, £500. The first are William Brodrick Cloete, William Shepherd, and Sebastian Camacho. Remuneration, until otherwise resolved in general meeting, £250, multiplied by the number of Directors for the time being, the same to be divisible as they may determine.

PROVISIONAL PATENTS, 1890.

AUGUST 25.

13319. **Improvements in electric bells and motors.** Joseph Townley, 377, Old Kent-road, London.

13337. **Improvements in electrical contacts.** George Forbes, 34, Great George-street, Westminster, London.

13344. **Improvements in galvanic batteries.** Herbert John Allison, 52, Chancery-lane, London. (Philip Hathaway, United States.) (Complete specification.)

13357. **Improvements in electromotors.** Alexander Siemens, 28, Southampton-buildings, London.

13358. **Improvements in the means for driving winches and other winding machinery by electrical motors.** Alexander Siemens, 28, Southampton-buildings, London.

13359. **Improved means for carrying electromotors on electrically-propelled cars or vehicles.** Siemens Bros. and Co., Limited, 28, Southampton-buildings, London. (Siemens and Halske, Germany)

13362. **Improvements in automatic telegraphs.** Edmund Edwards, 35, Southampton-buildings, London. (Eduard Cassalette and David Kunhardt, Germany.)

13371. **Improvements in electric bells and indicators.** Henry Jukson Harris and Willoughby Hamilton Power, 21, Cockspur-street, London.

AUGUST 26.

13410. **Improvements relating to electric semaphores.** Frederick Stitzel, Charles Weinedel, John Henry Egelhoff, Moses Schwartz, Adolf Reutlinger, and Jacob Krieger, 18, Buckingham-street, Strand, London. (Complete specification.)

13419. **Improvements in or relating to bending flat electrotype plates to a true circular form, and in apparatus therefor.** William Phillips Thompson, 6, Lord-street, Liverpool. (The Curved Electrotype Company, United States.) (Complete specification.)

13421. **Improvements in apparatus for working or welding metals electrically, and in the method of effecting the same.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles Lewis Coffin, United States.)

13434. **The Davies improved electric clock.** Samuel John Davies, 121, Dynevor-road, Stoke Newington, London.

AUGUST 27.

13463. **Improvements in and connected with zincs for galvanic batteries.** Joseph Moseley, 70, Market-street, Manchester.

13485. **Improvements in fittings for electric glow lamp conductors.** William White, 28, Southampton-buildings, London. (Complete specification.)

13491. **Improvements relating to electric belts, and to apparatus for use in connection therewith.** Cornelius Bennett Harness, 45, Southampton-buildings, London.

AUGUST 28.

13522. **Improvements in instruments for indicating or registering the state of the charge in accumulators.** Gaston Roux, 5, Villas de Couronnes, Rue Chanzy, Asnières (Seine), France.

13525. **Improvements in electricity meters for alternating or interrupted currents.** George Hookham, 7, New Bartholomew-street, Birmingham.

13535. **Improvements in electrical alarms.** Norcliffe George Thompson and George Henry Rew, 13, Victoria-street, London.

13549. **Improvements in and relating to converters of alternating currents.** Rankin Kennedy, 10, India-street, Kilmarnock. (Complete specification.)

13557. **Improvements in secondary batteries.** Theron Solyman Eugene Dixon, 28, Southampton-buildings, London. (Date applied for under Patents Act, 1883, Sec. 103, 6th February, 1890, being date of application in United States. (Complete specification.)

13570. **Improvements in and relating to telegraphic apparatus.** Bernhard Egger, 45, Southampton-buildings, London.

AUGUST 29.

13619. **Improvements relating to magneto-electric conductors for traction purposes.** Alexander Login Lineff, 6, Bream's-buildings, London.

AUGUST 30.

13635. **Improvements in or appertaining to electric welding.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles Lewis Coffin, United States.) (Complete specification.)

13636. **Improvements in electric welding.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles Lewis Coffin, United States.) (Complete specification.)

13683. **Improvements in electric switches.** Otto Romanze and Frederick William White, 4, South-street, Finsbury, London.

13699. **Improvements in electric bells or gongs.** Frederick Herbert Berry, 186, Fleet-street, London.

SPECIFICATIONS PUBLISHED.

1889.

12389. **Electrical contact maker, etc.** Houghton. 6d.

13154. **Constructing electrical coils.** Mather and Sumpner. 6d.

15567. **Propelling vehicles by electricity.** Kincaid and others. 4d.

19080. **Secondary, etc., batteries.** Cheesswright. 6d.

1890.

3731. **Secondary batteries.** The Mining and General Electric Lamp Company, Limited, and Fitzgerald. 4d.

8777. **Electric call bells.** Lake (Hathaway). 8d.

10181. **Secondary batteries.** Foote. 8d.

10515. **Electrical batteries.** Jarman. 6d.

10564. **Printing telegraphs.** Scott. 6d.

CITY NOTES.

West Coast of America Telegraph Company.—The receipts for August were £4,950.

Direct Spanish Company.—The traffic receipts of this Company for August were £2,075, against £1,624.

Brazilian Submarine Telegraph Company.—The receipts for the week ended August 29 amounted to £4,806.

Cuba Submarine Telegraph Company.—The traffic receipts of this Company for August were £2,900, against £2,815.

Eastern Telegraph Company.—The traffic receipts for August were £52,606, as against £52,012 for the same period of 1889, or an increase of £594.

Eastern Extension Telegraph Company.—The receipts for August amounted to £46,526, as against £39,469 in the corresponding period, showing an increase of £7,057.

West India and Panama Telegraph Company.—The estimated receipts for the half-month ended August 31 are £2,420, against £2,161. The May receipts, estimated at £6,398, realised £6,526.

Western and Brazilian Telegraph Company, Limited.—The receipts for the week ended August 29, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,772.

Companies of the Month.—The following electrical companies have been registered during the past month:

Gordon Electric Traction Syndicate, Limited, £10 shares	£2,400
Nonpareil Electrical Syndicate, Limited, £10 shares	6,000
Sheffield Telephone Exchange and Electric Light Company, Limited, £1 shares	100,000
Western Railway Company of Mexico, Limited, £10 shares	231,000

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	$1\frac{3}{4}$
— Pref.	—	$1\frac{3}{4}$
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	$5\frac{3}{4}$
London Electric Supply	5	2
Swan United	$3\frac{1}{2}$	$5\frac{1}{2}$
Crompton & Co., Pref.	—	$5\frac{1}{2}$
National Telephone	5	$5\frac{1}{4}$
Electric Construction	10	8

NOTES.

Edinburgh.—A special meeting of the Edinburgh Corporation has been called for the 7th of next month to consider the question of electric lighting.

Train Lighting in Russia.—Thirty trains have recently been fitted up from England for the Russian Government, and others are to be done.

B.A. Grants.—At the conclusion of the British Association meeting various grants were made for scientific purposes, among which was one of £100 for the Committee on Electrical Standards.

Automatic Air Pump.—Dr. Raps has recently described before the Berlin Physical Society an arrangement of Topler's mercurial air pump, by means of which he had made it work automatically.

Zurich.—The Municipality of Zurich are arranging with the Oerlikon Works for the establishment of a system of public and private lighting of 10,000 lamps of 16 c.p. and Brockie-Pell arc lamps for the streets.

Lineff System for Switzerland.—We understand that arrangements are being made by the Oerlikon Works, of Zurich, to introduce and work the Lineff system of closed-conduit electric tramway into Switzerland.

Sheep-Shearing Machines.—With reference to the note on sheep-shearing machines, the judges of the Sydney Agricultural Society at the last trial awarded £50 to Suckling's patent. The same amount will probably be awarded at the next trial.

Australian Eiffel Tower.—An Eiffel tower is, according to the latest accounts, to be erected in Melbourne, and a company with a capital of £100,000 has been formed to build it. The electric lighting contract for this, if it is true, will be worth looking after.

Central Station for Barnsley.—The Barnsley Town Council on Tuesday adopted the recommendation of a committee that the town clerk be directed to apply to the Local Government Board for sanction to borrow the sum of £23,000 required for electric lighting purposes.

Bavaria.—The town of Berchtesgaden in the Bavarian Alps will shortly be lighted by electricity, the installation to be carried out on the three-wire system by Messrs. Schuckert and Co. The motive power is obtained from an existing water power, in combination with a steam plant.

Bushbury.—The electric manufacturing works of the Electric Construction Corporation at Bushbury, near Wolverhampton, are rapidly approaching completion, and the picturesque village is destined to lose its sylvan aspect by the erection of some thousand or so workmen's dwellings.

Sheerness.—The price of the gas at Sheerness is £3. 2s. per lamp per year. A member told the Council electric light of 16 c.p. could be obtained for £2. 6s. The experience of town lighting, however, is that they would not be satisfied with 16-c.p. electric lamps if they are with gas of the same power.

Ferranti System in France.—The result of the application for further shares in the Compagnie Nationale de l'Electricité in France, for the further development of the Ferranti system, has been sufficient to allow the company at once to commence the proposed work both in the country and in Paris.

Naval Projectors in Mist.—Experiments of the French navy has served to show that powerful projectors are not effective in warfare. In misty weather the reflection and glare served only to blind the ship with their own light, and the torpedo-boats approached within easy distance and discharged their torpedoes without being discovered.

Electric Tricycles.—Mr. W. P. Browne, Chicago, is about to place three or four tricycles, driven by C. & C. motors that are operated by storage cells of the Pumpelly type, on the street for advertising purposes. The indications are that the device will prove profitable from the start, and applications are coming in from other cities for the use of machines.

Electric Lighting in Brazil.—The Brazilians are apparently appreciating the value of the electric light. Some time ago the Westinghouse Company sold a 1,500-light alternate-current incandescent plant for the Brazilian town of Juiz de Fora. The Juiz de Fora Company is well pleased with its purchase, and has ordered of the Westinghouse people a 750-light machine to supplement the present capacity of its central station.

The Telephone in Japan.—The Japanese Government has taken telephone matters into its own hands, and is starting an exchange in Tokio, which will shortly be followed by one in Yokohama. When both are in thorough running order they are to be united by trunk lines, the distance between the two cities being only 18 miles. The rental is to be equal to £10 per annum, with a small additional charge for use of the trunk line.

Electric Tramway for Leeds.—At a meeting of the Highways Committee of the Leeds Town Council on Wednesday, Alderman Firth presiding, a letter was read from the Electric Tramway Company, expressing a desire to enter into negotiations with the Corporation for the running of electric tramcars on the Roundhay Park route. After some discussion the matter was referred to the Tramways Sub-Committee.

Coloured Views.—The N.Y. *Electrical Engineer* comes out with a new feature this week. It gives a full-page illustration of the Crocker-Wheel perfected electric motor, printed in all the glories of colour—field magnets in blue-grey, the winding, armature, and terminals in resplendent yellow, and the commutator in a beautiful terra-cotta. As a work of art (and advertisement) it is certainly striking, but as an exact representation it is a trifle glaring. Truly, their views are coloured.

Engadine.—The syndicate formed by the three leading hotels of St. Moritz, in the Engadine, for the introduction of the electric light, having employed an expert, have had the tender of Messrs. Stirnemann and Wissenbach, of Zurich, recommended to them. Motive power will be supplied by three Girard turbines coupled direct to Ganz alternators. The station is about three miles from the hotels. This installation will consist at first of 4,000 lamps, but power is provided for extension in the district.

American Electric Railways.—It is stated that by the close of the present year the electric railway mileage in the United States will be double what it was at the close of last year. By this showing there will be no insignificant measurement, seeing that there were completed in 1889 very nearly 1,900 miles of electric railway. In the course of three years 180 towns have adopted this system of locomotion, and the total number of passengers carried in this way, last year, amounted to 200 millions.

Journal.—The *Journal* of the Institution of Electrical Engineers has been issued, containing the report of the meeting of the Institution at Edinburgh, with Prof. Ayrton's paper on the "Working Efficiency of Secondary Cells," and full abstract of the discussion. It also contains the reply of Mr. K. L. Murray to the discussion on his paper describing the lighting of the Melbourne Exhibition with tests; and also the description of a "Proposed System of Alarm Wires on Submarine Cables," by H. Kingsford.

Japanese Lighting.—There are, according to the latest figures, over 11,000 electric lights in Japan operated from central stations, besides a large number of installations, and this number will be doubled within the year. The Tokio Electric Light Company has four stations, equipped for 6,200, 2,200, 2,200, and 2,200 lights respectively, and other notable plants are at Kyoto (2,200), Kobe (2,200), Asaka (3,500), and Nagoza (1,600). Most of these stations are now running about half their capacity, and are putting in new lights rapidly.

Tenders for Dublin.—Some important electric lighting contracts are now becoming open, and among these that of the city of Dublin is not the least. The Corporation have now advertised that they will receive tenders on or before Monday, the 13th of October next, for the electric lighting of the streets. The parties tendering are required to supply and erect the whole installation. Specifications and forms of tender, with ground plan and site of streets, can be had of the borough surveyor, on the payment of three guineas. The tenders must be forwarded to the Town Clerk, City Hall, Dublin.

Frankfort Exhibition.—From reports that we receive of the efforts and arrangements that are being made for the forthcoming electrical exhibition at Frankfort, it would seem as if the Germans were determined to make it a real and great success. The lighting will consist of about 10,000 glow lamps and 1,000 arc lamps, and there will be 2,200 h.p. available. Intending British exhibitors should notice that applications for space from foreign countries to this exhibition will be received only till the end of this month, and should make the arrangements with the authorities accordingly.

Edinburgh International Exhibition.—The East of Scotland Engineering Association held a special session at the exhibition on August 5th and 6th. Amongst the papers read was one on the "Protection of Buildings from Lightning," by A. R. Bennett, vice-president of the association, in which the effects of several recent storms in Scotland on buildings and telegraph wires were described; and one descriptive of the telephonic exhibits, by C. G. Wright, fellow. The remaining papers dealt with the mechanical exhibits, the one by Prof. Elliot, on the Locomotive Annex, being specially noteworthy.

Phosphor-Bronze.—To electrical engineers requiring a tough metal for the cogwheel gearing of tramcars, for bearings and bushes, the phosphor-bronze offers many advantages. A new catalogue of the Phosphor-Bronze Company, of Sumner-street, Southwark, gives particulars of their various makes, and also of silicium-bronze electric wire for overhead lines. For the latter, the company present many important testimonials. They also describe their white metal, and other specialities. The catalogue is about to be issued to the public, and those who wish to make use of their products should send for it.

Electric Omnibuses.—The Ward Electric Car Company are intending to run their line of electric omnibuses from King's Cross to Victoria. They are expected to start almost every day. Seven 'buses are nearly ready, and each 'bus is to carry 26 passengers, 12 inside and 14 outside, with a driver and conductor. The passenger fare is to be the same as the General Omnibus Company, the whole journey being 3d. The 'bus will be worked by 60 19-plate E.P.S. accumulators fixed in the bottom of the car. They will work about three hours a day, and then freshly charged for another run.

Utilising Artesian Wells.—There is an interesting application just before the Municipal Council of Paris for the erection of an electric central station in order to utilise the power of a new artesian well situated in the Herbert-place, La Chapelle. The well, being 750 yards deep, throws the water up to a height of 38 yards, and gives 215,000 cubic feet of water in 24 hours. Several turbines are intended to drive dynamos and to supply electric light and power to the surrounding districts, which are mostly industrial, and therefore promise a large consumption. The lighting of the adjacent park, Buttes Chaumonts, will be done from the same generating power.

Monmouth.—Electricity, we should fancy, would soon be a welcome guest in Monmouth. Owing to disputes with the gas company, who want to charge £4 a lamp a year for public lighting, instead of £3, the price offered by the Corporation—at the last meeting of the Town Council, it was practically decided to abandon gas for the use of petroleum. Oil will, therefore, in all probability be adopted, though not, we think, for permanency. We know the steps: grasping gas company, disputes, discussions, and proposals; threats of petroleum, advantages of electric light discussed, trial, and final adoption of electric light. Let us hope the dispute will come out this way with Monmouth.

A Million Shocks.—In the account of the British Association, rightly or wrongly, Mr. Preece is reported by the *Daily News* to have said that during a lifetime of investigation he had received a million electric shocks. A correspondent thereupon wrote to object, thinking that Mr. Preece has yet but an imperfect appreciation of the value of a million. He says: "Assuming that he has so devoted 40 years, and taking the year as consisting of 52 weeks (scientifically inaccurate, but near enough), and allowing six working days, each of 12 hours, to the week, I find that in every working hour Mr. Preece must have received on an average 6·666 shocks, or one shock in about every nine minutes!"

Electrolytic Protection of Ironwork.—A process for preventing oxidation of artistic wrought ironwork for outdoor purposes, other than a coat of paint, is described in *La Lumière Electrique*. The iron or steel work is in this process plunged as the anode into an electrolytic bath containing from ½ to 5 per cent. of chloride of manganese with from 5 to 20 per cent. of nitrate of ammonia. A carbon cathode is used, and the bath is not heated. A feeble current only is needed, such as may be obtained from an ordinary electric battery. The result of the electric action is to cover the ironwork with a deposit of peroxide of manganese that effectually protects the metal from the inroads of rust.

Dublin.—Mr. C. P. Cotton, C.E., local government inspector, will hold an enquiry at the City Hall, Dublin, on September 12, with reference to an application made by

the Corporation to the Local Government Board for sanction for certain loans. The sanction is required because the sum proposed to be borrowed, together with outstanding loans under the Sanitary and Public Health Acts, would exceed more than one year's assessable value of area liable to taxation. The sum sought to be borrowed amounts to £63,000, which consists principally of a sum of £50,000 required for the purpose of an installation under the Electric Lighting Act, and a sum of £3,000 for the purchase of ground and erection of buildings for gas and meter testing offices.

Electric Acid Bath for Photogravures.—The *Papier Zeitung*, of Berlin, announces that an important discovery has been made in the art of engraving and especially in photogravure. As usual, the design to be engraved is placed on a zinc plate either by photography or by an artist; this plate backed by a coating of asphaltum is then placed in an acid bath. In the new process the plate is put into connection with a dynamo machine and the current is led away by a wire placed in the bath. As soon as the circuit is established the acid attacks the metal with an astonishing rapidity, and a few minutes are sufficient to bite in several millimetres deep. The depth of engraving can thus be easily regulated, a difficult matter under the ordinary process.

Kidsgrove Works.—The following are the particulars of the transfer of the new works alluded to in a recent note. Woodhouse and Rawson United, Limited, have taken over the business of King, Masterman, and Terry, of Union Foundry, Kidsgrove, Staffordshire. Messrs. Masterman and Terry will undertake the management of the works, and Mr. H. Sampson King will represent Messrs. Woodhouse and Rawson at their Westminster offices, 16, Great George-street, S.W. By this arrangement, Woodhouse and Rawson United will have at their disposal an old-established engineering works, situated in the heart of the Staffordshire coal and iron district, and possessing direct railway and canal communication with all parts of the kingdom, and will be in a position to manufacture and supply complete plant for electric lighting stations with all accessories.

Morse Signalling at Sea.—On Monday night the gunboats "Mastiff" and "Blazer," with the ocean tug "Seahorse and torpedo-boat No. 42, have been engaged under the superintendence of Captain Galway, of the "Hecla," torpedo depôt ship, in carrying out a series of experiments at Spit head with the new electric signalling lamp. The flotilla left Portsmouth shortly after sunset, and the various vessels being stationed at fitted distances apart, one off the Bembridge Ledge, a second beyond the Warner light ship, and the others nearer in shore. A succession of flashing signals were exchanged by the Morse code from one to the other so as to test the reading of the alphabet at different ranges, the practice being kept up from nine o'clock until nearly midnight. The results so far under favourable atmospheric conditions and a smooth sea appear to have been very favourable.

Jarman Electric Cars.—It is expected that the Jarman Electric Tramcar Company will start to run two electric tramcars to and from Clapham and Vauxhall next week. The cars are built to match other trams as near as possible. They are to be driven by a 12-h.p. double armature motor, each armature developing 6 h.p., worked from 104 19-plate E.P.S. cells, giving 45 amperes at a pressure of 208 volts. The armatures can either be worked together in parallel, or in series, or singly. The motor when going at its nominal speed will run at 650 revolutions per minute, propelling the car at eight miles an hour. When unloaded it weighs 5½ tons, and loaded eight tons. There is very little noise heard working the car, as one of the cogwheels in each gear is made of compressed paper. When running at full speed it can be stopped in a very short space. It is fitted up with six 100-volt lamps to light the car.

Moving Keeper Dynamos.—Mr. Gisbert Kapp, in a letter to *Industries* last week, refers to the Klimenko dynamo. "This," he says, "is not, strictly speaking, a moving keeper dynamo, but simply a machine with revolving field magnets. The latter consist of a central hub mounted on the spindle, and four radial prongs, or poles, on either side all the prongs on one side being south and all the prongs on the other side north poles. The exciting coil, which is placed around the central hub, does not revolve. The armature coils have laminated iron cores, and are placed parallel to the shaft, so that their ends are swept over by the revolving field poles. The number of armature coils is double that of field poles. It will be seen from this description that the Klimenko alternator is simply a Mordey machine, with iron in the armature, and a stationary instead of a revolving field coil. It is in no way an anticipation of Mr. Kingdon's alternator."

Westminster Supply.—As we have already informed our readers, the Westminster Electric Supply Company are building three electric light stations, one for Westminster, one for Belgravia, and one for Mayfair districts. The one for Westminster is expected to be running at the end of this month. In this there are to be three boilers of Babcock and Wilcox make, each one indicating 120 h.p., Willans high-speed engines, and Goolden's dynamos. In the meantime, while the buildings are being finished, two temporary stations are still running, one being used entirely to light the House of Commons, and the other lights the mansions around the district. The latter consists of two boilers, one 40 h.p., and one 20 h.p., two Willans high-speed engines, and two Crompton dynamos, also 60 31-plate Crompton accumulators, which are run in parallel with the machines. The three-wire system is to be adopted on the Westminster Company's circuits.

Submarine Navigation.—Who is to be the deep sea Columbus ? asks Captain Prince Dakkar Nemo in a little brochure, reprinted from the *Bootle Times*. The Captain Prince is prepared to be it himself, and has promulgated his idea of a submarine vessel, cylindrical, 12ft. diameter amidships, 60 ton weight, carrying 30 tons of E.P.S. accumulators, and geared by motors to double-acting propellers on a system which he has applied himself. He mentions 1 to 1,000 h.p. to be exerted, a run of 1,000 miles at a low rate of speed, or an extreme of 30 miles an hour at the highest speed, and says if ever he found himself in command of such a vessel as pourtrayed, he "would enter into a rigid contract to perform much more" than he has hinted at. He looks to the era of small electric submarine vessels as having set in, thinks both for skirmishers, and for guiding the laying of telegraph cable, as well as for recovery of sunken goods, such boats would be invaluable, and also quick, steady, short sea passages, as from Dover to Calais, could be undertaken by these vessels regardless of wind and tide. For salvage work particularly he considers these ocean divers can be made useful and practical, and is prepared to take charge of one at the first opportunity that can be offered to him.

A Liquid Car Gearing.—One of the great difficulties in the application of a quickly rotating engine, like the ordinary electric motor, to the propulsion of tramcars, or, in fact, the driving of any heavy machinery, is the disadvantage it offers in the starting of the load. A rush of current tends to take place as the motor starts, and some method of enabling the motor to gradually take up its load has been often sought. One of the most bold and original attempts to accomplish this is explained by Mr. E. S. Pillsbury in a recent number of the N.Y. *Electrical Engineer*, where a turbine is advocated as an intermediate gearing, or rather a combination of pump and turbine, constituting a liquid gearing. In effect the armature is coupled to a rotary pump, and the car wheel axle to a turbine; these two are enclosed together in a small iron vessel with water. The armature starts at full speed driving the pump, and the turbine takes up the speed evenly and gradually, the two being locked when the speed becomes equal. As, for high-speed turbines, a 15in. wheel of modern build will give 350 h.p. at 600 revolutions, it is easy to see that the size of the arrangement need not be great. The car might in this way be managed with one switch, and be reversed without being overtaxed. It remains to be seen whether the arrangement proposed is more practical than the usual method of resistance to reduce the strength of field magnets.

Telephonic Theory.—The theory of the actions taking place in the telephone, at one time supposed to be charmingly simple, has been found to be far more complex than original experimenters imagined. A writer in *L'Electricien* of the somewhat Scottish name of D. MacNab has a thoughtful article upon the subject, entitled "The Thermic Theory of the Microphone." He considers "the theories of the microphone based upon the variation of resistance as the point of contact must be abandoned. . . In reality, the theory is complicated, very complicated," and he gives calculations and curves of the harmonics of sounds. He says, in effect, that he considers the mechanism of the microphone comprises thermal effects, and that heat plays the part of transformer analogous to that of magnetism in the telephone. Carbon has a great capacity for heat, and hence its usefulness. For a perfect microphone (1) the carbons must be polished; (2) the points of contact must be numerous and close together; (3) the points must be easily movable; (4) the carbons must have little inertia. The granulated carbon microphones used in Paris fulfil these conditions. He adds the microphonic effect can be greatly increased by heating the carbon contacts. A loud-speaking telephone should have "warmed carbons." He brings forward two conclusions from these views: (1) A filament of carbon of high resistance and small mass heated and fixed to a diaphragm should act as a microphone; (2) the microphonic effect should be reversible, that is, a suitably-arranged microphone should act as a telephone.

Faraday's Catalogue.—We gave in our issue of Aug. 22 a notice of the new catalogue of Messrs. Faraday and Son, of which we had an advance view. This catalogue is now issued, and we may supplement our remarks upon the beauty and delicacy of the designs of artistic fittings which appear therein, by referring more particularly to the actual kinds of fittings. As we mentioned, the drawing in of the background in light touches to most of the designs is a pleasing and noticeable feature, which will tend to commend the catalogue to the actual user. All the drawings have been specially redrawn for this catalogue, and many new designs have been added, which now are issued to the public for the first time. The first plates are devoted to brackets, and we are presented with some very effective pieces of ornamentation. Here are heavy chased brackets with either delicate hanging lace shades or cut glass globes; we have bronze figures, leaf shades, and grotesques; simple light twisted brackets, and those of hammered leaf. Next we have pendants, little lamps with coloured glass friezes for alcoves; egg-shaped etched pendants, Roman lamps chain-hung with candle-shaped incandescent lamps; Turkish and other Eastern shapes; dining-room dome lights with coloured silks and fringes, and wrought brasswork; hall lamps, saloon and drawing-room pendants, light and elegant or solid and massive, with three lamps or with 20; lamps for staircases, hanging above or standing on the newel-posts. Then there are numerous coronas with the light rolled brass filagree work which Faraday's have made a speciality. Afterwards come standards, and of these the shapes are too numerous to be separately mentioned, evincing the favour with which portable electric lights for table writing-desk, or reading-chair are regarded. Among these, several designs of little bronze cherubs holding lamps in various attitudes are extremely effective. The book is one which those who have to do with the fitting up and decorating of better-class articles should by no means be without.

Central Station in Brussels.—The first central station for the distribution of electric light in Brussels, established in the Passage du Nord by the Tudor Accumulator Company, consists, according to details given in the *Bulletin Internationale de l'Electricité*, of the following plant: two 50-h.p. condensing steam engines, by Rider Bollinck; two Mattot boilers, specially constructed for erection in the narrow passage; two dynamos of 16,800 watts each (140 volts and 120 amperes), constructed by the Thomson-Houston Company, and one dynamo of 40,000 watts (140 volts and 290 amperes) by Siemens and Halske, of Berlin. Shafting permits either engine to drive any dynamo. To avoid shaking of the neighbouring premises the engines are mounted on special foundations. Over the machine-room is the accumulator-room, containing 264 cells grouped in four parallel series of 66. The cells are composed of plates 550 by 420 mm., of a total weight of 230 kilog. (about 5cwt.) each. Their useful capacity is 756 amperes [ampere-hours], with a charging current of 95 amperes, and a discharging current of 126 amperes. The station in full working order can supply 2,000 lamps of 16 c.p. The parallel two-conductor system is used. The overhead conductors consist of phosphor-bronze insulated cable, 36/10, dividing into four circuits, each capable of feeding 1,500 lamps of 16 c.p., or their equivalent. A signal apparatus, both for ear and eye, gives notice to the electrician when the pressure in the mains varies one volt over or under normal. The staff of the station consists of an electrician, an engine driver and stoker. The principal customer to the station at present is the Café Métrôpole, which takes 600 lamps of 16 c.p. Switches are arranged to allow the separate illumination by groups of the interior, the upper rooms, the cellars, and the exterior in front on the pavement. The distribution in this establishment is excellent, and makes a brilliant display. Another important installation is that of MM. Cartaut, who take 400 lamps of 16 c.p. The station has already a guaranteed minimum for 10 years by contract, amounting to 35,000f. a year. The installation was erected by M. Vandewiele, under the direction of M. H. Kratz, formerly managing director of the Tudor Company, and now director of the electric lamp company at Schaerbeck.

THE EDINBURGH EXHIBITION.—XV.

Stand No. 83. Sir William Thomson's Instruments.

For the measurement of potential in connection with electric lighting or power installations on board ship, the mass of the moving part of the balance voltmeter is too great to be convenient for accurate use. The marine voltmeter, Figs. 1 and 2, now to be described is specially suitable for such a purpose, but it is also equally useful as a portable voltmeter for general use.

The instrument consists of a small oblate of soft iron supported on a stretched wire in the centre of a solenoid of fine copper wire connected in series with platinoid resistances, variable according to the potential to be measured; and is founded on the principle that an oblate spheroid of soft iron, movable round a diameter, tends to turn its equatorial plane parallel to the lines of force in a uniform magnetic field. The pointer is fixed relatively to the oblate in such a manner that, when the pointer is at the zero position of the scale, the equatorial plane of the oblate is inclined about 45deg. to the lines of force of the solenoid.

The suspending wire is stretched between the two ends of a brass tube, being fixed at the bottom end and carried

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Fig. 2.—Section.

at the upper end by a torsion head, which is secured by screwing down upon it the movable cap of the top resistance coil. Portions of the tube are cut away to permit of easy access to all parts of the instrument for adjustment or inspection. In order to prevent damage to the suspending wire or accidental disturbance of the torsion head, two copper cylinders, which also serve to carry the resistance coils, are placed covering the two ends of the supporting tube, and are fixed by screws to the sheath.

The scale is graduated from zero to 140, but for convenience of observation the first marked division is 50. It is placed in a horizontal box with a glass cover fixed to the sheath, and the pointer shows, by inspection, direct reading of currents of from 50 to 140 milliamperes.

The resistances to enable the instrument to be used as a voltmeter are wound anti-inductively on two copper cylinders, and the lower one of these may be arranged to serve as a convenient means of supporting the instrument on a table or shelf. When, as is most commonly the case, the mean potential to be measured is 100 volts, the platinoid resistance is adjusted to make up, along with the fine copper wire solenoid (of which the resistance is about 60 ohms), a total resistance of 1,000 ohms. Thus the direct reading of potential on the scale is in volts.

In order to save time in taking readings a checker is provided. A brass arc, capable of moving in a vertical direction, is placed parallel to and slightly below the plane in which the pointer moves, and by means of a handle this arc may be brought gently and momentarily into contact with the pointer so as to quickly stop its oscillations.

When the instrument is to be used for very accurate work, a means of observing and annulling any error due to residual magnetism in the oblate may be provided by a reversing key placed below the scale box, and two magnets screwing into the sheath. The current through the instrument is made in one direction when the handle of the reversing key is in the top position, and made in the opposite direction when the handle is in the bottom position. The current is broken when the handle is on either side. The residual effect in the instrument is very small, and it is found to be sufficiently accurate for all practical purposes without this adjustment.

The adjustment for annulling any effect due to residual magnetism in the oblate may be tested by taking two readings with a constant current passing through the coil, first in one direction and then in the other. If the readings so obtained do not agree, the current should be reversed through the coil several times by turning the handle of the reversing key—in most cases this will be found sufficient to restore the adjustment. Should it not do so, recourse

Fig. 3.—The Ampere Guage.

must be had to the two compensating magnets in the case, which should be simultaneously screwed out or in as required until the desired equality of readings is obtained. When this is done the magnets should be again clamped by means of the nuts provided for that purpose. When it is found necessary to screw out the magnets to make the above compensation, and on screwing them out as far as possible a perfect adjustment cannot be obtained, the two magnets should be interchanged, and the desired compensation will then be speedily secured by screwing them in a little.

The ranges of the different types of the ampere-gauge usually made are:

I.	From	·25	to	5	amperes.
II.	„	1	„	20	„
III.	„	5	„	100	„
IV.	„	10	„	200	„
V.	„	25	„	500	„

The instrument, Fig. 3, is of simple construction, having a vertical slate base-plate to which are attached:

(*a*) A solenoid of special form.

(*b*) Brass bearing plates supporting a balance which carries a soft iron plunger on its one arm and a brass counterpoise weight on the other.

(c) A brass arc having a scale graduated to give direct readings in amperes.

(d) A hinged arm which bears a light checker.

The solenoid is built up of copper plates with mica insulation between them, and is fixed to the base-plate so that its core is vertical.

The balance is supported on knife edges at such a distance below the solenoid that the top end of the plunger is slightly entered into the core. The plunger is made from a thin soft iron wire about 20 centimetres long, and is supported by a crossbar with two hooks on it, which pass over two knife-edge stirrups on the arm of the balance. It has a brass weight hung on its lower end in order to keep it in a vertical position and prevent its being attracted against the side of the solenoid.

An indicating needle, or pointer, formed from a strip of platinoid, passes down from the trunnion of the balance to the brass arc bearing the graduated scale. As the plunger is attracted upwards, this pointer passes round the scale and indicates the strength of current passing through the solenoid.

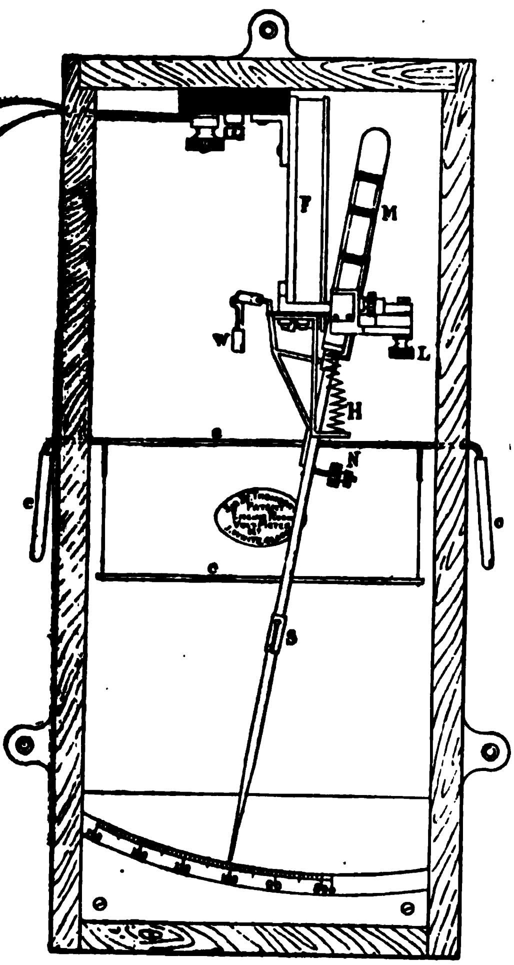


Fig. 4.—Engine Room Voltmeter.

This new engine-room voltmeter, shown in Fig. 4, is intended for installation work on either direct or alternating circuits, where it is convenient to have a direct-reading voltmeter with large scale divisions.

The instrument depends for its action upon the repulsion of a movable coil, M, by a fixed coil, F. The fixed coil, F, bears all the other portions of the instrument attached to it, and is in its turn supported from a vulcanite block fixed to the instrument case. This vulcanite block also bears the terminals of the instrument. The movable coil is supported on knife edges, and the circuit through it from the fixed coil of the voltmeter is made by two spirals of fine copper wire. A pointer attached to the movable coil indicates by direct readings in volts the difference of potential between the terminals of the instrument. Attached to the pointer on one side, and perpendicular to it, is a short arm with a screw nut, N, which, together with the sliding weight, S, on the pointer, serves to adjust the balance of the movable parts. To the other side of the pointer is attached a bracketed arm terminating in a knife-edged stirrup, on which is hung the weight, W, fixing the constant of the instrument.

The movable coil can be lifted from its bearings by turning the screw, L, which raises a lever passing below the knife-edge trunnions, and so fixes the movable portion of the instrument when the instrument is being removed from place to place, or is packed for carriage.

A checker, *cc*, is provided to facilitate the taking of readings when the circuit is for some reason being made and broken, or the potential being suddenly and largely varied.

The instrument is graduated by direct comparison with a standard centiampere balance. The movable portion is first adjusted to be in neutral equilibrium by means of the sliding weight, S, and the nut, N. The weight, W, is then hung on the knife-edged stirrup. This weight causes the pointer to come back to zero, in which position the movable coil is pressed against the fixed one, and is adjusted so that the pointer just begins to indicate at the lowest point to which it is desired to work. The scale consists of very nearly equal divisions, and is usually graduated from 80 or 90 to 140 or 150 milliamperes. The coils of the instrument are wound with many turns of copper wire, and have a total resistance of about 100 ohms. An anti-inductive resistance of platinoid wire is fixed to the back of the instrument, and is adjusted to make up, with the resistance of the coils, 1,000 ohms at a given specified temperature. Thus, as the scale is in milliampéres, the instrument reads directly in volts.

(To be continued.)

ON ANTI-EFFECTIVE COPPER IN PARALLEL CONDUCTORS OR IN COILED CONDUCTORS FOR ALTERNATE CURRENTS.*

BY SIR WILLIAM THOMSON, F.R.S.

1. It is known that by making the conductors of a circuit too thick we do not get the advantage of the whole conductivity of the metal—copper, let us say—for alternate currents. When the conductor is too thick, we have in part of it comparatively ineffective copper present; but, so far as I know, it has generally been supposed that the thicker the conductor the greater will be its whole effective conductance, and that thickening it too much can never do worse than add comparatively ineffective copper to that which is most effective in conveying the current. It might, however, be expected that we could get a positive augmentation of the effective ohmic resistance, because we know that the presence of copper in the neighbourhood of a circuit carrying alternate currents causes a virtual increase of the apparent ohmic resistance of the circuit in virtue of the heat generated by the currents induced in it. May it not be that anti-effective influence such as is thus produced by copper not forming part of the circuit can be produced by copper actually in the circuit, if the conductor be too thick? Examining the question mathematically, I find that it must be answered in the affirmative, and that great augmentation of the effective ohmic resistance is actually produced if the conductor be too thick; especially in coils consisting of several layers of wire laid over one another in series around a cylindric or flat core, as in various forms of transformer.

2. Fig. 1 may be imagined to represent the secondary coil of a transformer consisting of solid square copper wire in three layers. For simplicity we suppose the axial length to be infinitely great, and straight; but the uniformity which this involves, and a close practical application to its simplicity is realised in that excellent form of transformer which consists of a toroidal iron core completely covered by primary and secondary wires laid on toroidal surfaces. To simplify the mathematical work I suppose the whole thickness of the three layers to be small in comparison with the greatest radius of curvature of the circular or flat cylindric surface on which the wire is wound, but if it is not so the solution is easily obtained for the case of circular cylinders in terms of the Fourier-Bessel functions. It is of no consequence for our present question what there be

* Paper read before the British Association.

inside of coil No. 3, and if we please we may imagine there to be nothing but air. The drawing, however, indicates an iron core and space which might be occupied by the primary coil if a transformer is the subject, or our coil, A A A A, may be the primary coil of a transformer with secondary coil and core inside it, and the alternate current maintained in it by an external electromotive agent acting in an arc between its ends outside. Our present results are applicable to all these varieties of cases indifferently, all that is essential being that the total quantity of current be given at each instant, and be uniform throughout the whole length of the coiled conductor.

3. This last condition is secured by perfectness of insulation between all contiguous turns of the coil, unless we were considering so enormously long a coil that the quantity of electricity required for the essential changes of static electrification would be sensible as constituting drafts from, or contributions to, the current in the coil. The consideration of static electrification, involved in the maintenance of alternate currents through a coil such as that represented in Fig. 1, is exceedingly curious and interesting; but we do not enter on it at present at all, as in all practical cases the quantities concerned are quite infinitesimal in comparison with the whole quantity flowing in one direction or the other in the half period.

4. In the drawing the section of the wires is represented as square; but this is not essential, and in practice a flat

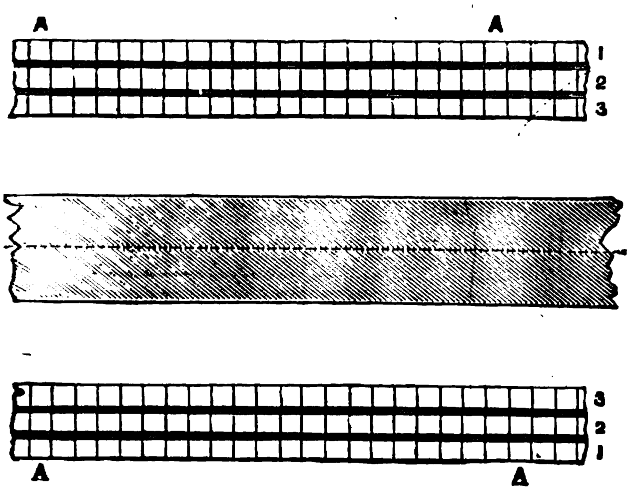


FIG. 1.

rectangular ribbon would, no doubt, for some dimensions of coils be preferable. I assume the thickness of the insulation between the successive squares or rectangles in each layer to be infinitely small in comparison with the breadth of the rectangle; but the thickness of the insulation between successive layers, which is a matter of indifference to my calculations, may be anything, and would in practice naturally be, as shown in the diagram, considerably greater than the thickness of the insulation between the contiguous portions of the coil in each layer.

5. The full mathematical work which I hope to communicate to the *Philosophical Magazine* for publication in an early number includes an investigation of the self-induction of the coil with or without anything in its interior (such as core or primary wire of a transformer); but at present I merely give results, so far as effective ohmic resistance, or generation of heat in the interior of the wire of the coil A A A A itself, is concerned, which, as said above, is independent of everything in the interior, and of the mode in which the alternating current is produced, provided only that the total amount of electricity crossing the section of the wire per unit of time be given at each instant.

6. As a preliminary to facilitate the expression of these results, it is convenient first to give a general statement of the solution of the problem of laminar diffusion of a simple harmonic variation, applied to the case of electric currents in a homogeneous conductor. Let the periodically varying magnetic force in the air or other insulating material in the neighbourhood of so small a portion, S, of the surface of a conductor that we may regard it as plane, be given. Resolve this magnetic force into two components, one, perpendicular to S, which we may neglect, as it has no influence in connection with the currents we are to consider; the other, parallel to S, which we shall call the effective component and denote by Y. Through any point O, of S, draw three rectangular lines, O X, O Y, O Z, of which O Y and O Z are in S, and O X is parallel to the direction of the effective magnetic force component, Y. Let now the value of Y at time t be

$$Y = M \cos \frac{2\pi t}{T},$$

where M denotes a constant, and T the period of the alternation. The varying magnetic force, Z, to whatever cause it may be due, gives rise to currents parallel of O Z in the conductor, expressed by the following formula for γ, the current intensity at distance X from the plane S, provided T be small enough to fulfil the condition stated below:

$$\gamma = \frac{M}{\lambda\sqrt{2}}\,\epsilon^{-\frac{2\pi x}{\lambda}} \cos\left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda} + \frac{1}{4}\pi\right);$$

where λ denotes what we may call the wave-length of the disturbance, and is given in terms of T, the period of the disturbance, and ρ and Π the resistivity and magnetic permeability of the substance, by the following formula:

$$\lambda = \sqrt{\frac{T\rho}{\Pi}}.$$

For copper we have $\Pi = 1$, and $\rho = 1{,}611$ square centimetres per second; and thus for 80 periods per second $\lambda = 4{\cdot}49$, or, say, $4\frac{1}{2}$ centimetres. In order that the formula for γ may be approximately true, it is necessary, in the first place, that λ must be small in comparison with the distance we must travel in any direction in the surface of S before finding any deviation of it from the tangent plane through O comparable with λ. Secondly, for a very good approximation, λ be so small that we may be able to travel inwards in any direction from O, through a space equal to at least twice λ, without coming to any other part of the bounding surface of the conductor. If, for example, the surface be a flat plate, this condition requires that the thickness be more than twice λ. But (because $\epsilon^{-\pi}$ is less than $\frac{1}{23}$) the formula gives a very fair approximation requiring for half the thickness of the plate inwards from S no greater correction than about 4 per cent., even if the thickness of our plate be no greater than λ. When the thickness of the plate is less than 2 λ, we may consider waves of electric current as travelling inwards from its two sides, and being both sensible at the middle of the plate; and a complete solution of the problem is readily found by the method of images. But a direct analytical investigation, by which the proper conditions of relation to varying magnetic force on the two sides of the plate are fulfilled is the most convenient way of fully solving the problem, and it is thus that the results given below have been obtained.

7. The smallness of the insulating space between the successive turns in each layer of our coil, A A A A, and the equality of the whole current through them all prevent any surface disturbance from being produced at the contiguous faces, and allow the problem to be treated as if instead of a row of squares or rectangles we had a continuous plate forming each stratum. The smallness of the thickness of this plate in comparison with the radius of the cylindric surface to which it is bent allows, as said above, the mathematical treatment for an infinite plate bounded by two parallel planes to be used without practical error. I have thus found an expression for the intensity of the current at any point in the metal of any one of the layers of a coil of one, two, three, or more layers, and have deduced from it an expression for the quantity of heat generated per unit of time, at any instant, per unit breadth in any one of the layers. I need not at present quote the former expression. The latter is as follows: With q to denote the dynamical value of the time average of the heat generated per unit of time at different instants of the period, per unit breadth and unit length in layer No. i, from the outside of the coil, c^2 the time average of the square of the total current per unit breadth, and a the thickness of the layer.

$$q = \frac{2\pi\delta}{\lambda}\Theta c^2,$$

where

$$\Theta = \frac{\epsilon^{2\theta} + 2\sin 2\theta - \epsilon^{-2\theta}}{\epsilon^{2\theta} - 2\cos 2\theta + \epsilon^{-2\theta}} + 2i(i-1)\frac{\epsilon^{\theta} - 2\sin\theta - \epsilon^{-\theta}}{\epsilon^{\theta} + 2\cos\theta + \epsilon^{-\theta}},$$

and $$\theta = \frac{2\pi a}{\lambda}.$$

8. The numerical results shown in the table have been calculated, and the accompanying graphic representation, Fig. 2, drawn for me by Mr. Magnus Maclean.

TABLE OF VALUES OF Θ.

$\frac{16\theta}{\pi}$	$i=1$	$i=2$	$i=3$	$i=4$
1	5·113	5·118	5·127	5·141
2	2·553	2·592	2·669	2·786
4	1·316	1·634	2·270	3·224
6	·9854	1·997	4·019	7·053
8	·9173	2·993	7·143	13·37
10	·9452	4·062	10·30	19·65
12	·9822	4·899	12·73	24·48
14	1·000	5·276	13·83	26·66
16	1·002	5·362	14·08	27·16
∝	—	5·000	13·00	25·00

9. We see from the table and curves that each curve has a minimum distance from the line of abscissas, and that each comes to a horizontal asymptote, parallel to the line of abscissas, for $\theta = \infty$. By looking at the formula we see that there is, in fact, an infinite succession of minimums and maximums in the expression for Θ; but it is only the

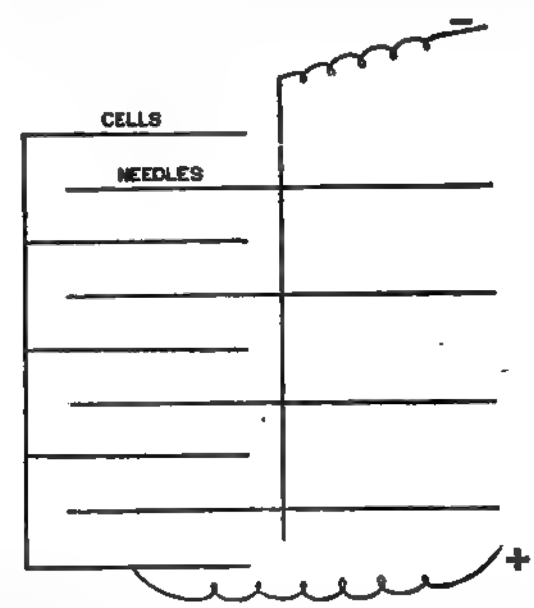
FIG. 2.

first minimum and following maximum that occur within the range of variation of Θ, which we regard as sensible. In the case of $i=1$ the formula gives $\theta = \frac{1}{2}\pi$ for the first minimum. The curves show for the cases of $i=2, 3, 4$, respectively, the first minimum at $\frac{16\theta}{\pi} = 4\frac{1}{2}$, 3, and 2·6 respectively. The thickness which corresponds to $\theta = \pi$ is the half-wave length of the electric disturbance, which, as we have seen, is for copper 2·244 centimetres when the frequency of the alternations is 80 periods per second, and for this case, therefore, the thicknesses that give minimum generation of heat in the first, second, third, and fourth layers are respectively 11·22, 6·31, 4·21, and 3·65 millimetres. Anything more of continuous copper than these thicknesses in any of the layers would be not merely ineffective or comparatively ineffective, but would be positively anti-effective. Even with so small a thickness as 2·8 millimetres, for copper and frequency 80, line 2 of the table (corresponding to a sixteenth of the wave-length) shows, in the first, second, third, and fourth layers losses of 0·3 per cent., 2 per cent., 5 per cent., and 10 per cent. in excess of that due to the true ohmic resistance of the copper were it all effective. When the size chosen for the transformer and the amount of output required of it are such that a thickness of $2\frac{1}{2}$ millimetres in the direction perpendicular to the layers is insufficient, a remedy is to be had by using braided wire, or twisted strand, with slight insulation of varnish or whitewash, crushed or rolled into rectangular or square form of the desired thickness and breadth. A very slight resistance between the different wires thus crushed together would suffice to cause the current to run nearly enough full bore to do away with any sensible loss from the cause which forms the subject of this communication.

ON AN ILLUSTRATION OF CONTACT ELECTRICITY PRESENTED BY THE MULTICELLULAR ELECTROMETER.*

BY SIR WM. THOMSON.

Contact electricity of strong metals absolutely removed from possibility of chemical action is a subject which was formerly much discussed, but now the fact of that kind of action is thoroughly admitted, and most of the natural history of the subject is pretty well known. I have not to-day to add to the knowledge of the subject, but merely to remark that it brings out a very curious feature in electrostatic instruments, in illustrating its application to this instrument of contact electricity. The metals in question are brass and aluminium. I am sorry I cannot show you the interior of the instrument just now, but a sketch will probably make it understood. The instrument consists in a multicellular electrometer. In its working it is a number of cells, as the



designation indicates, with a needle, or a number of needles, moving under the influence of these cells. There are 20 cells, one over the other, and we will represent this in section.

There are 10 cells acting on one set of ends and 10 at the other. The needles are mounted one above the other on a stem which hangs by a fine platino-iridium wire. The principle is simply this, the needle is connected through its fine wire with the outside case of the instrument, which is one of the metals between which the difference of potential has to be measured. The other metal is the cells—this pile of cells and the other pile of cells are metallically connected. They are insulated from the outer case of the instrument, and we have a binding screw here connected metallically with the cells: and insulated from the case of the instrument we have another binding screw. The instrument is adapted to measure difference of potential between these two metals. It is analogous to the quadrant electrometer with its needles and quadrants used as two bodies, the needle connected with the case of the instrument. In the quadrant electrometer contact electricity was illustrated by making the two pairs of quadrants, say, of zinc and copper. I have noted a very different manifestation of contact electricity

* Paper read before the British Association.

presented by this form of electrometer. Let us suppose that the needles and the cells are maintained at a difference of potential of, say, 100 volts, this instrument before you is adapted to work at potentials of from 60 to 120 volts. If the needles were polished aluminium and the cells polished aluminium we should have none of the difference due to contact electricity. You get apparently 100 and $\frac{3}{10}$ or $100\frac{1}{4}$ when the needles are positive and the cells negative; on the other hand, when the needles are negative and the cells positive you get $99\frac{3}{4}$, the mean being correctly 100 volts. I anticipated this when the instrument was first made, but our first trials of all first instruments within the year of preparation showed such effect to a degree so little that it could barely be perceived. You could barely see $\frac{1}{10}$ of a volt difference. We made more than a year ago a great many careful experiments, and never found more than $\frac{1}{10}$ of a volt. Quite lately my attention was recalled to this by my former assistant, Mr. Rennie, now of the Board of Trade testing laboratory which has lately been established under the superintendence of Major Cardew. He found, with a new instrument recently supplied to that laboratory, a larger difference of just about the amount we originally expected. I have tried new instruments since, and found it much greater than in the earlier trial instruments. The explanation is that in the original instruments that were made for trial, with pieces of metal that had been tossed about in the laboratory, and with needles and plates unpolished, the condition of surface was not such as to give the proper difference. But in the finished instruments, with a high polish a definite difference of this kind, much greater than in the original trial instruments, was obtained. I received a letter this morning from Mr. Rennie about experiments on an electrometer at the Board of Trade.

In the course of these experiments at the Board of Trade, extending over a month or six weeks, and made at frequent intervals, there were doubled differences amounting from ·5 to ·6. There was evidence of a slight decrease in the error, and it is not at all improbable that in time this error may diminish when the initial state of polish may have become toned down. I made one experiment of that kind, subjecting an instrument, just as it stood, both cells and needles, to damping by vapour of water; but the result was not to diminish the difference, but rather to augment it. But exceedingly little change takes place. The explanation is, of course, that polished aluminium is positive to brass, just as zinc is positive to brass, and the effect is of the same kind as would be observed if we had zinc needles and copper cells, the form of contact electricity with which we are most familiar. Let us suppose, instead of being connected to a battery, a metallic connection is made between the cells and the needles; then we shall have a simple contact difference between aluminium and brass. A direct experiment on the force due to that would show no result. Let us say $\frac{1}{4}$ volt is the difference.

The force due to this difference when the terminals are metallically connected bears to the force due to it, when a difference of 100 volts is maintained between them, the ratio of $(\frac{1}{4})^2$ to $(100+\frac{1}{4})^2-100^2$, or approximately 1 to 800.

Prof. Fitzgerald repeated an already published warning against instruments of this kind, particularising a guard-ring electrometer, in which the movable part was of aluminium, and the guard-ring of brass, and there was a difference of potential between the aluminium disc and the brass guard-ring. This disturbed the uniformity of the distribution of electricity, and in delicate experiments would have to be calculated for. It would be much better in instruments of this kind that the parts subject to attraction should be made of the same material.

NOTES ON HIGH VACUA.*

BY J. SWINBURNE.

I.

In a series of papers on "Incandescent Lamp Manufacture," I called attention to the great superiority of the Geissler to the Sprengel form of mercury pump. Several kinds of Sprengel pump were successively connected to a Geissler, and both were worked at the same time. The Sprengel invariably stopped taking air down before the Geissler; in fact, the Geissler never stops. It acts as its own McLeod gauge, and never indicates a perfect vacuum. The probable reason why the merits of the Geissler have been so underrated is that it needs the greatest care in securing perfect dryness of the bulb and valve. Not only will traces of water vapour condense under the floating valve instead of lifting it and going through, but it is probable air does so too. About a century ago Davy showed that if the mercury were allowed to run up gently in an imperfect Torricellian vacuum, a bubble was left; but if allowed to rise suddenly, it indicated a perfect vacuum, the air being condensed against the glass. In the lamp papers I described a form of pump which avoids difficulties due to small condensations. The main bulb discharges into a small chamber sealed by a little V tube, so that a pressure of 1/100 A would move the mercury. This chamber exhausts into a larger globe, exhausted mechanically, and sealed by a floating valve. The small chamber is thus as thoroughly exhausted as an ordinary pump can pump it; but the pump proper, exhausting into high vacuum, can thus work better. The condensed air and water cannot expand back into it. It is thus really a double pump, or two mercury pumps in series. The only drawback is that it needs some pressure to open the first valve or sealing, so that there might, after all, be some condensation under it. I have lately devised and used a pump

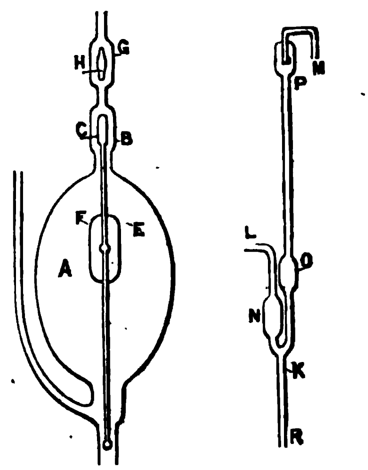


FIG. 1. FIG. 2.

made as follows: A is the body or chamber of the pump proper. This exhausts into the small chamber B, sealed by the valve C, and this exhausts into the chamber G, sealed by the floating valve H. G is connected to a reservoir and mechanical air pump. The valve C has a long thin glass rod passing down through A into the lower tube, which acts as a guide. A loose sleeve, F, is strung on this rod. There is a swelling at E which fits the lower end of the sleeve, and is small enough to pass through the neck in putting the pump together. When the mercury rises in the globe A it lifts the sleeve till the lower end catches on E, which closes it. The mercury rises, and floats the sleeve, thus lifting the valve C. The mercury that sealed C then runs out, and there is a clear passage through into B; so no condensation takes place in A. The mercury rises till it floats H. When it falls, the valve C acts again, for the mercury has filled the sleeve, F, over the top, and C is heavy enough to sink the sleeve and rod when the sleeve is full of mercury. I have tried electromagnetic and other arrangements; but this is the best as far as I have gone.

When using a pump it is best not to let air, and perhaps moisture, run through it more than can be helped. By the use of a sort of syphon it is possible to seal on new work to be exhausted without letting the air pressure into the pump.

The point K is the barometric height at which the mercury normally stands in the tube, R. There is then a clear passage between L, which is connected to the tubes to be exhausted, and M, which goes to the drying tubes and pump. When a tube has been sealed off and a new one is to be put on, the mercury reservoir at the foot of the arrangement is raised so that the bulb N is filled. A tap at the foot of the tube, R, is closed and the vacuum in L is

* Paper read before the British Association.

broken. The mercury then runs up to the new barometric height, P. The new tube is then sealed on and exhausted by a mechanical pump, the connection being then sealed off. The mercury in the long tube then stands only half an inch or so above that in N, and on opening the tap at the foot of R, the communication is made again to the pump. The small bulb, O, and the trap at the top are to prevent a plug of mercury from going round into the phosphoric tubes.

The pump is driven by water so as to be self-acting, and can be left running for any length of time. Those who have worked much with mercury pumps will realise the value of this. Nothing makes one feel the futility of life more than to exhaust something by hand which cracks at the last stage, when five hours of life have been ticked off.

II.

In the same papers on lamp making I urged that the methods of measuring high vacua were inaccurate and completely misleading. The McLeod gauge and the induction coil are usually relied on for testing vacua. In incandescent lamp work the induction coil is almost exclusively used. With the test by induction sparks, I have, at present, nothing new to add, and will confine myself to the McLeod gauge. In measuring vacua with this gauge it is assumed that the mercury itself has no vapour tension. The vapour tension of mercury has been given by Regnault as about 50 millionths of an atmosphere. If it is anything like this, of course a vacuum of one millionth, or of ·005 millionth, as some experimenters profess to have reached, is absurd. When discussing this subject at the Society of Arts after Dr. S. P. Thompson's well-known paper on "Mercury Pumps," Prof. Ramsay gave ·25 millionth of an atmosphere, or, as I shall write it shortly, ·25M., as the vapour tension of mercury at ordinary temperatures.

The whole action of a pump is consistent with a vapour tension of from 25M. to 50M. A Geissler does not reduce the pressure in geometrical progression; but when it gets a good vacuum it takes out very little air each stroke, worked fast, and much more if worked slowly. This looks as if when the tension of mercury vapour was nearly reached, the air taken out at each stroke was what diffused into the mercury vapour. This would also explain why a Geissler, which goes on long after a Sprengel stops, does not so readily make a sparkless tube. A Sprengel stirs up the mercury, and gives the tube being exhausted more chances of getting filled with mercury vapour, which is a non-conductor. This also explains why so many experimenters get better vacua with hot mercury. Of course a new pump should be heated to get the moisture off the glass, but not when it is in ordinary use.

To test this more directly I attached two McLeod gauges to the same pump. They communicated till a fair vacuum was reached. One was then sealed by raising the mercury past the elbow tube. The gauges were allowed to communicate by lowering the mercury every now and then, and it was always lowered before taking a reading. By this arrangement, when the pressure was reduced nearly to the vapour pressure of mercury, one gauge might have little but mercury vapour, and show a good vacuum; while the other had air at the same pressure, and showed a pressure equal to the vapour tension of mercury, or nearly so. The gauges are graduated by finding $p\,v$ corresponding to one millionth of an atmosphere, and graduating accordingly. The pressure in millionths is then the product of the reading on the closed tube and the difference in the column. Each reading is thus readily taken at several pressures to make sure there is no condensation of any vapours or gases. The readings obtained varied in an extraordinary way. When the exhaustion was carried so far that the open gauge registered 2M. or 3M., the closed registered from 20M. to 60M. The least difference in temperature seems to make a large difference in the readings. In some cases, when the vacuum was still low, the open gauge was heated till the mercury sputtered, and condensed about the bulb. The bulb was then warmed to evaporate the mercury and drive all the air out, and the elbow tube sealed by raising the mercury. When the gauge was cool both were unsealed and readings taken. The gauge that had been warmed sometimes gave 1M. against no less than 230M. in the other. Ten minutes' connection generally brought the readings equal. Obviously the movement of the air need not depend on diffusion only; for a very small difference of temperature would cause mercury to evaporate in one gauge and condense in the other, driving the air with it.

I made a gauge with an alloy of about equal parts of potassium and sodium, which is liquid at ordinary temperatures. It would, of course, absorb any mercury vapour, and has probably a low-vapour tension. It was very troublesome, for it could not be exposed to the air for a moment, and heavy hydrocarbons would prevent the pump's working. The alloy always gets some moisture, and gets coated with a thin film of oxide which prevents drops from uniting, and they can only be run together by heating under a hydrocarbon of low boiling point. I eventually got the gauge fitted up, but the alloy acted on the film of moisture on the glass, and the bubbles formed seemed to drive plugs of it about. It has a very low specific gravity, and pistons of it began to stray about inside the pump, and I was afraid they might get to the mercury, and by combining explosively, smash the pump, so the experiment was abandoned. In one experiment a plug did wander into the tube, R, and cracked it.

Fusible alloy was next tried. It worked better, but the vapours of some sulphur that was used to trap any mercury vapour blackened the surface, and only two readings were obtained. These gave a pressure of only 13·5M. as the vapour tension of mercury.

Whether it is really 13M. or 50M. is of comparatively little importance; but there seems to be quite enough evidence that the readings of ·01M., and higher vacua that have been given, are inaccurate to the extent of some hundreds of thousands per cent. This is important in many investigations pursued by means of mercury pumps, for instance, experiments on the "Fourth State of Matter." The question is also important in lamp making, as it shows that better vacua are possible, and they may be an advantage. I do not know whether pumps worked with alloy of sodium and potassium will come into commercial use.

FRITSCHE COMBINED INCANDESCENT AND ARC LIGHT PLANT.

It may, perhaps, be of interest to give a few details of a combined incandescent and arc light installation which has been put down by the firm of Fritsche and Pischon, in Berlin, for the Duisburg Engineering Works, Limited.

The steam engine is of the horizontal single-cylinder type, without condensation, manufactured by the Karlsruher Maschinenfabrik, and gives about 37 actual h.p. at 180 revolutions per minute. A Fritsche patent wheel-armature dynamo, Fig. 1, is used, and by a so-called cross-joint coupling it is coupled direct, in order to allow for a small mutual displacement of the shafts. Both machines are very satisfactory in running. The accompanying cut gives a general view of the new wheel-armature dynamo (without copper in the armature), in which the arrangement of the brushes may be seen clearly on the periphery of the armature.

The switchboard is of somewhat remarkable construction. The shunt regulator, as shown in Fig. 2, has its resistance coils formed by nickelin wires, which are fastened on porcelain insulators on a cast-iron frame, the construction being hidden by an elegant decorative cover of perforated sheet iron. Nickelin is a kind of German silver, composed of 23 per cent. Ni, 54 per cent. Cu, 20 per cent. Zn, 1 per cent. Fe, 0·5 per cent. mang., specific resistance = 0·4117.

The construction of the switchboard is given in Figs. 3 and 4. The two main collecting bars, an ampere-meter and a voltmeter are mounted on a cast-iron tablet with wrought-iron rails, and insulated therefrom by pieces of vulcanised indiarubber, so that the whole switchboard becomes extremely simple, simplicity having been the principal aim in the design of the machinery. As there are no belts for driving the dynamos, the usual sliding arrangements became superfluous, and the dynamos could be mounted on a rigid stone foundation like the steam engine. Contrary to other larger installations, where the number of regulating and controlling apparatus increases far beyond proportion to

the number of lamps, the plant in question for 38 arc lamps (6 amperes), one arc lamp (9 amperes), and about 125 glow lamps, all of which are not burning at one time, requires but a small switchboard with only two measuring instruments, owing to the particular arrangement of the distributing wire system.

The dynamo-room is situated about 20 yards from one end of the workshop building (136 yards in length), so that the distance between dynamo and remotest lamp amounts to 160 yards.

The quantity of light required for the central part of the spacious building, which serves as fitting-room, while both sides are reserved to the mechanics, changes considerably; besides there being a relatively large number of arc lamps, it would have been found very inconvenient to join each arc circuit separately to the switchboard, and also the numerous lengths of wire between machine-house and workshop would have given rise to troubles of all kinds. These inconveniences have been overcome by running a closed ring circuit of bare stranded copper wire on insulators outside the central part of the building, providing several connections on both sides into the interior. Both incandescent and arc circuits are branched off this ring circuit through suitable fuses.

Fig. 1.—Fritsche Dynamo, Without Copper in Armature.

Fig. 2.—Shunt Regulator.

On account of an existing installation, which is to run temporarily from the new dynamo, and also for economical reasons, the dynamos are wound to give a pressure of 70 volts at their terminals, so that each arc lamp has its separate circuit, and may be turned on or off quite independently of all the others. A steady working of such an arrangement necessitates a very constant P.D. on all points of the ring circuit, this P.D. only varying within very close limits. This condition is fulfilled by several feeders running from the collecting bars on the switchboard to different points of the ring circuit, at equal distances from each other (ring system of Fritsche). For this ring circuit (360 yards length) four positive and four negative feeders are provided, and the same number of controlling wires are run from the feeding joints back to the voltmeter at the generating station, in order to ensure an efficient regulation and control of the P.D. in the ring circuit.

The arc lamps burn very steadily in spite of the varying load, and their 38 regulating resistances are all alike, as the arc lights are fixed at equal distances, so that it is not necessary to regulate each of them for its special circuit.

A comparison between the plant as here described and an installation of five or six years ago, where glow lamps and arc lamps were run from separate machines (for instance, six arc lamps and 100 glow lamps required four dynamos) shows the great progress electric lighting has made since then.

Fig. 3.—Fritsche Switchboard.

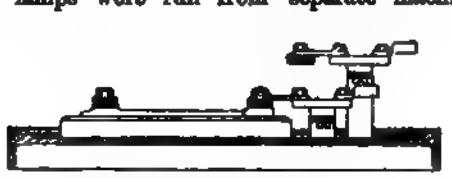


Fig. 4.—Section of Switchboard.

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PROSPECTIVE AND RETROSPECTIVE.

The British Association meeting at Leeds has come and gone. In attendance it has not been so successful as some previous meetings, in papers and discussions there has been the usual luxuriant crop, good, bad, and indifferent. We shall not now attempt to estimate the value of the electrical papers, that will be better done after the papers are before our readers.

Next year the association meets at Cardiff as early as the 19th August, under the presidency of Dr. Huggins, while the following year the meeting is to be at Edinburgh. One of the features of the last day's work during any meeting is the confirmation of the grants recommended by the committee. We cannot help thinking that the work of the various investigators to whom grants are allowed forms, if not the most valuable, at least one of the most valuable features of the association. The reports obtained are frequently of a bibliographical character, and give in a small compass the references necessary to trace the development of that particular phase of scientific work about which the report is made. Electrical science especially has much cause to thank the British Association. It was due to its action that the question of units was considered, and to a certain extent settled. It is due to its action that the history of the B.A. standards is being written, and annually we hear of any changes that may have occurred in the standards. The constant supervision of standards thus carried on, however, not only gives information about them, but incidentally is throwing light upon the action of time upon the various materials employed. The amount of the grants this year towards electrical objects is £115 out of a total of £1,335 granted, though there are several committees appointed to report upon such subjects as "Magnetic Observations," "Electro Optics," "Silent Discharge of Electricity," which do not receive grants of money.

The early time at which the Cardiff meeting is to be held is not likely to become a precedent, for the general committee refer to the council the propositions "that it is desirable to fix the meeting two years in advance, and to bear in mind that the latter end of September is the most convenient time" for each meeting. Many members think the beginning of September on the whole preferable. The holidays of those engaged in collegiate work may be somewhat interfered with, but for the bulk of members the work of the winter commences about the end of September, and with many in the middle of September. However, the time of meeting should simply be that most convenient for the majority, and if the majority prefer the end of September there is nothing more to be said.

A modification of the method of admission to the

general committee might be suggested to the council. All annual subscribers of over five or over ten years' standing, and all life members, should be placed on the general committee without application or other formality. It goes without saying that a member who becomes a life member, or who continues his subscription from year to year for a number of years, conclusively shows his interest in scientific progress, and his opinion is as valuable in matters of organisation as that of the newly-fledged professor, whose claim is his professorship or the contribution of a few papers.

Another proposition referred to the council relates to the desirability of a more "full and expeditious publication of papers with reports of discussions upon them." This is a double-barrelled gun, which, no doubt, the council will quietly shelve. The *Proceedings* now form a very thick volume, and to increase its size to any great extent would necessitate a publication of two volumes at an increased cost to the association. Its earlier publication is a much simpler matter, and eminently desirable. One of the recent secretaries—was it not Mr. J. E. H. Gordon?—tried all he knew to hurry the publication of the *Proceedings*, and, unless rumour is mistaken, his efforts were only partially successful, and this want of success was due entirely to the bigwigs contributing desultory papers and not furnishing the necessary abstract or the paper to the secretary. It is supposed that all papers, or abstracts, shall be in the hands of the secretary at the close of the meeting, and the sections try to fall in with this good intention. But reports are *not* finished at the time of reading; they have to be finished, and the secretary gets them as best he may. It is not impossible to indicate the principal culprits, though naught would be gained by so doing. Again, time is lost when a discussion is recommended to be printed. Those who took part in the discussion have to write out their remarks, or supposed remarks, for the discussion as it appears in the official print is as little like the real discussion as stick is to stone. It may be taken for granted that every section is fairly reported in the technical press reporting that section, so that the necessity for the papers in full with the discussion in the *Proceedings* is not so apparent. The reports in the technical press are generally completed within about a month of the meeting, far sooner than the *Proceedings* could possibly be issued.

In the present article we can only refer casually to the subject of accepted papers. These contain too great a leaven of pure advertisements. In one glaring case this year, in Section G, an apparatus was described that was partly patented fifteen years or so ago. It has long been an article of commerce, and has been described again and again in the technical papers. The reason why the paper was sent to the British Association is palpably evident, and should have procured its rejection. It is extremely difficult to draw the line when recent applications are described, but there ought to be no difficulty with things five, ten, or fifteen years old. One paper of this kind does more harm than twenty good ones. The British Association is not a medium to obtain a cheap and effective advertisement, and if men want to advertise their old wares, they should be politely told to do so at their own expense in the usual way.

BATH.

It is perhaps better to give the causes of the difficulties that have been noticed and commented on at Bath than to leave the matter in doubt. At least that is the opinion of our correspondents, one of whom has placed the facts before us, which are as follows:

"The arc lamps were most unsteady between 10 and 11 p.m., August 30th, the cause being the engineer-in-charge had allowed his steam to drop from 150lb. to 108lb.—the dynamos being slowed down until the blowing arrangement (Thomson-Houston) ceased to act, the sparks flashing round the commutator.

"On Sunday evening, August 31st, all the glow lamps were out from 8 p.m. for the remainder of the evening. Forty-eight of the street arc lamps were out from 8.45 to 12, all the street arcs (some 83 in number) being out from 11 to 12 p.m.

"I met the police going into the station to report 'lamps out,' and went in with them.

"The station was in a state of semi-darkness, the men having to work the best way they could with two smoky paraffin lamps and three or four candles.

"The stoppage was due to an inability to get water into the boilers.

"The injectors have been in a state of general uselessness for about a month or six weeks.

"The engineer was depending entirely on one little donkey-pump for the feed-water, and the suction-pipe of this pump got jammed up with a piece of spun-yarn about the size of your fist.

"There was no rose fitted to the end of the suction-pipe, and no covers to the tanks from which the feed-water was drawn."

Our correspondent noticed all the high-tension fuses and switches fitted only a few feet from the ground, and, as yet, totally uncovered or protected in any way, while boys aged from 14 to 16 are engaged from 5 to 12 p.m. to work the rheostat in the exciter circuit, and sit within a foot of all this unprotected gear.

It is quite natural to want to commence running directly it is possible, and too frequently the few final touches are "procrastinated" as soon as running commences—hence troubles. This seems the case at Bath, otherwise covers to tanks, and

protectors to switches, most certainly ought to be provided and in place.

TESTING IRON.*

BY J. SWINBURNE AND W. F. BOURNE.

In practical work iron has to be tested as to its permeability and as to the loss by hysteresis. As regards permeability tests, the ordinary ballistic galvanometer method can, of course, be used; but a ballistic galvanometer is not a convenient instrument, and the method is too slow for practical use. It may, therefore, be of interest to describe the apparatus we use commercially. It is the development of a method devised in 1886. (See *Phil. Mag.*, July, 1887.)

The various samples of iron are obtained in the form of wire, made up into rings, being wound on a former kept for the purpose, so that all the rings are alike as to dimensions. Before winding, the specific gravity of the iron is taken by weighing, and the specific resistance is measured. The ring is weighed to get the volume of iron, and is then wound with suitable primary and secondary wires.

The arrangement is shown diagrammatically in the annexed figure:

The circuit from secondary cells is led through an adjustable resistance, then through an ammeter to a commutator, resembling Brillouin's, which is driven by a belt from any shafting that may be near. The circuit is led through the primary to an induction box to the ring under test, and then back to the commutator. The circuit is then led back to the cells. The induction box consists of a primary coil, standing on end, and a number of secondary coils arranged so that the mutual induction is the same for all of them. The secondary coils are led to buttons, and the switches include them by ones or tens, making the readings in steps of one per cent. of the highest. The primary of the sample ring is in series with that of the induction box. The secondaries are coupled so as to oppose each other, and arranged in circuit with a second commutator; a Varley, or, as it is more often called, a Deprez-d'Arsonval galvanometer, being inserted in the circuit. The two commutators are, of course, on the same spindle. The adjustment of the induction box was carried out as follows: The coils were roughly calculated to give a mutual induction a little in excess of a convenient round number per turn of secondary. A cylinder of a known diameter with a known number of turns per centimetre in the primary and a known number of turns in the pilot coil was taken, and put in the place of the sample ring, and its mutual induction measured with the induction box. To allow for the error due to the shortness of the cylinder of the standard coil, it was slipped out of the pilot coil, and moved exactly half its length in a direction along its axis and a new reading taken. This reading gave the error due to the ends of the cylinder. A shunt was then put across the primary induction box, so as to make the readings come out in microhenrys.

To test a sample of iron all that is necessary is to alter the mutual induction by steps, and to bring the galvanometer to zero for each step by means of the adjustable resistance. As the galvanometer is dead-beat, the readings can be taken in a few minutes.

The importance of loss by hysteresis in alternate-current work is only now beginning to be fully realised. There are several ways of measuring the loss in transformers, but none of them seem satisfactory. Sometimes the transformer is put in a calorimeter, or else it is assumed that the pressure and even the exciting current vary harmonically, and have a so-called "angle of lag." The published efficiencies of most transformers are got by finding the loss from the copper resistances, and neglecting the loss in iron altogether. There is still another method, and that is taking the curves of pressure and current. Prof. Ryan has been singularly successful in this with a modification of Joubert's method.

Tests of transformers by means of lag angles and calorimeters have been published by Profs. Ferraris and Ayrton, and Major Cardew. As the loss in a transformer can be divided into the loss in the copper which varies as the square of the load, and the loss in the iron by hysteresis and Foucault currents which remains constant, these results can be checked. The results published, as obtained by these experimenters, show inaccuracies that make them quite valueless. The loss in the iron in Prof. Ayrton's experiments varies 160 per cent. of its smallest value, while Prof. Ferraris's cores give out power working as refrigerators. (See article "On Induction and Other Things," *Electrical Review*, October, 1887.)

There is really little reason for measuring the loss in a transformer; it is much simpler to measure the loss in the iron. No one would think of measuring the loss in the copper by means of a calorimeter or angle of lag method. All that is needed is to measure the effective current and multiply its square by the resistance, the resistance being determined from the specific resistance of copper, or by direct measurement. Similarly, in the case of the iron, it is best to determine the qualities of the iron once for all, and then the efficiences of all transformers made of it can be foretold.

We use the same rings as for the permeability test, but do not employ the secondary wires. The loss of power at various frequencies and inductions is taken with a wattmeter. It is sometimes supposed that a wattmeter cannot be made with little enough self-induction to read accurately. If there is much self-induction in the pressure or shunt circuit, the reading will be lower than that with a direct current if there is no self-induction in the circuit in which the waste of power is to be measured; but if the current is behind the pressure, as in measuring the loss in iron, the wattmeter may even read too high. We therefore designed a special instrument, which was made for us by pupils of the London College of Electrical Engineers. The current coils are fixed, and the moving coil is suspended by a fine wire, with a fine spring at the foot, to take the electricity out again. The moving coil has few turns and little self-induction, and a large non-ductively wound resistance is in series with it. This wattmeter can be read with a mirror, if desired; but with 2,900 ohms in series with the pressure coil, it gives a torsion of 2deg. per watt on a non-inductive resistance. The series resistance is not wound with a looped wire as is usual in resistance boxes, because this method is not good, the insulation being apt to break down. A single wire was therefore used. When one layer was wound, the bobbin was reversed in the lathe, and the next layer wound in the opposite direction, a thin layer of insulation being put between the layers. This method secures absence of self-induction, and good insulation, as the beginning and end of the coil are kept well apart. The readings are taken by bringing the index back to zero by turning the suspension, so that the mutual induction of the coils is zero, as the coils are at right angles.

The self-induction of the pressure coil was not directly measured, as that would give us no useful information, as we do not know the variation of the current and pressure of air dynamos. They certainly do not vary harmonically, and at full load the pressure rises slowly and falls suddenly in each half period.

The wattmeter was therefore subjected to a severe test. Readings were first taken with direct currents on a resistance; readings were then taken on the same resistance with an alternate current. This resistance had very little self-induction, so that any self-induction in the pressure coil should lessen the reading, by making the current in the pressure coil lag, and also by reducing it. The reading with

* Paper read before the British Association.

the alternate current was 2·1 per cent. less than with the direct. This figure is entered in the note-books, but though it is too small to matter in our work, it is larger than it ought to be. The next test was to measure the power taken by a coil with the same current and same pressure, but with no resistance and large self-induction. It is difficult to make up a coil with no iron core to take 50 volts and 10 amperes with no appreciable loss by resistance; we therefore took a hedgehog transformer and measured the power taken by it. The reading was taken with 50 volts and 4·2 amperes. If the pressure coil had any appreciable self-induction, the reading would be considerable; it might, in fact, be anything up to about 200 watts. The least self-induction would increase the reading enormously. The reading was 11 watts, and the calculated loss by copper and iron in the transformer with only 50 volts on its secondary was 10·3; so the wattmeter is practically correct Let it be supposed, however, that the loss in iron was really less than this, and that the loss was two watts less than the reading. This is an extreme assumption, but we may see how much such an error would affect our readings of the sample rings. The assumed error is 1 per cent. of the product of the pressure and current. Now, in the case of a closed iron circuit the power is about half the product; so this would lead to an error of 2 per cent. in the loss in the iron. In a closed-circuit transformer the loss in iron is, roughly speaking, 10 per cent. at full load, and about 40 per cent., to take a low figure, taken over the day, so that the error would be 0·2 per cent. and 1 per cent. In the hedgehog form the loss in iron is about 1·5 per cent. at full, and 15 per cent. at all day loads, so the errors are ·03 and 0·3 per cent. respectively, which are too small to matter. As a matter of fact, they are much less than the various errors of observation that creep into such work. Measuring the power in an open-circuit transformer is also a most difficult case, for the least self-induction then gives rise to the largest error; in measuring the power in a closed circuit ring the errors are less.

We give a number of curves of permeability and of $\int E\, dQ$ per cubic centimetre for different samples of iron. These are practically the same as curves of $\int I\, dH$; but $\int E\, dQ$ seems a better way of writing it, as $\int I\, dH$ can scarcely be said to have any physical meaning, and has even had the effect of not suggesting that the reversal involves waste of energy; indeed, it seems to have rather disguised the fact.

In completing these curves some corrections have been made. The wattmeter absorbs some power itself, as the pressure coil circuit is led through the current coils. We might have compensated for this in one of the ways described to Section A by one of us in 1887, but in this case did not think it worth while. The Foucault current losses are also corrected. The losses in the wires themselves can be calculated with rigid accuracy, as explained in a paper on "Transformer Design," which one of us had the honour of reading before Section G last year. There might also be some loss by Foucault currents, due to imperfect insulation between the wires of the core. The insulation is, however, too good to allow this. In fact, the resistance between two wires about an inch apart runs into ohms, the measurement being seven ohms in the particular example taken. The losses by Foucault currents are frequently over-estimated by writers on the subject. If the specific resistance of the iron is known they can nearly always be calculated with much greater accuracy than they can be measured. The loss by the copper resistance is also allowed for in the curves. Though it is generally the practice to give all the steps in a paper like this, we think it better to give the results only, for though the paper then looks less imposing than if full of curves and calculations, it is more likely to be useful.

We have not yet tested the same sample at very different frequencies to see if there is any time lag. From the comparatively small loss at high frequencies it is not probable there is any appreciable time lag.

THE CITY AND SOUTH OF LONDON ELECTRIC SUBWAY.

We have kept our readers informed from time to time of the progress of the electric subway railway which is to run from the City to the South of London, passing under the River Thames. Only slight information has been given, as the railway has not yet been thrown open to inspection of the technical press, and full details are promised as soon as the work is complete. A semi-public view was held, it is true, some months ago, at which a train was run from one end to the other, but this was not open to the technical press. Since then we have made occasional enquiries as to its progress, but have found the engineers at present very unwilling to give any but the most scanty information. The road is now very

mass; that the internal, not the external, magnetisation is the important fact to be considered; that the so-called free magnetism on the surface is, as it were, an accidental phenomenon; that the magnet is really most highly magnetised at those parts where there is least surface magnetisation; finally, that the doctrine of surface distribution of fluids is absolutely incompetent to afford a basis of calculation such as is required by the electrical engineer. He requires rules to enable him not only to predict the lifting power of a given electromagnet, but also to guide him in designing and constructing electromagnets of special forms suitable for the various cases that arise in his practice. He wants in one place a strong electromagnet to hold on to its armature like a limpet to its native rock; in another case he desires a magnet having a very long range of attraction, and wants a rule to guide him to the best design; in another he wants a special form having the most rapid action attainable; in yet another he must sacrifice everything else to attain maximum action with minimum weight. Towards the solution of such practical problems as these the old theory of magnetism offered not the slightest aid. Its array of mathematical symbols was a mockery. It was as though an engineer asking for rules to enable him to design the cylinder and piston of an engine were confronted with receipts how to estimate the cost of painting it.

Gradually, however, new light dawned. It became customary, in spite of the mathematicians, to regard the magnetism of a magnet as something that traverses or circulates around a definite path, flowing more freely through such substances as iron, than through other relatively non-magnetic materials. Analogies between the flow of electricity and in an electrically-conducting circuit, and the passage of magnetic lines of force through circuits possessing magnetic conductivity, forced themselves upon the minds of experimenters, and compelled a mode of thought quite other than the previously accepted. So far back as 1821 Cumming experimented on magnetic conductivity. The idea of a magnetic circuit was more or less familiar to Ritchie, Sturgeon, Dove, Dub, and De La Rive, the last-named of whom explicitly uses the phrase "a closed magnetic circuit." Joule found the maximum power of an electromagnet to be proportional to "the least sectional area of the entire magnetic circuit," and he considered the resistance to induction as proportional to the length of the magnetic circuit. Indeed, there are to be found scattered in Joule's writings on the subject of magnetism some five or six sentences which, if collected together, constitute a very full statement of the whole matter. Faraday considered that he had proved that each demagnetic line of force constitutes a closed curve, that the path of these closed curves depended on the magnetic conductivity of the masses disposed in proximity; that the lines of magnetic force were strictly analogous to the lines of electric flow in an electric circuit. He spoke of a magnet surrounded by air being like unto a voltaic battery immersed in water or other electrolyte. He even saw the existence of a power, analogous to that of E.M.F. in electric circuits, though the name, "magneto-motive force," is of more recent origin. The notion of magnetic conductivity is to be found in Maxwell's great treatise (vol. ii., p. 51), but is only briefly mentioned. Rowland, in 1873, expressly adopted the reasoning and language of Faraday's method in the working out of some new results on magnetic permeability, and pointed out that the new flow of magnetic lines of force through a bar could be subjected to exact calculation; the elementary law, he says, "is similar to the law of Ohm." According to Rowland, the "magnetising force of helix" was to be divided by the "resistance to the lines of force"; a calculation for magnetic circuits which every electrician will recognise as precisely as Ohm's law for electric circuits. He applied the calculations to determine the permeability of certain specimens of iron, steel, and nickel. In 1882, and again in 1883, Mr. R. H. M. Bosanquet brought out at greater length a similar argument, employing the extremely apt term "Magneto-motive Force," to connote the force tending to drive the magnetic lines of induction through the "magnetic resistance," or, as it will be frequently called in these lectures, the magnetic "reluctance" of the circuit. In these papers the calculations are reduced to a system, and deal not only with the specific properties of iron, but with problems arising out of the shape of the iron. Bosanquet shows how to calculate the several resistances (or reluctances) of the separate parts of the circuit, and then add them together to obtain the total resistance (or reluctance) of the magnetic circuit.

Prior to this, however, the principle of the magnetic circuit had been seized upon by Lord Elphinstone and Mr. Vincent, who proposed to apply it in the construction of the dynamo-electric machines. On two occasions they communicated to the Royal Society the results of experiments to show that the same exciting current would evoke a larger amount of magnetism in a given iron structure if that iron structure formed a closed magnetic circuit than if it were otherwise disposed.

In recent years the notion of the magnetic circuit has been vigorously taken up by the designers of dynamo machines, who, indeed, base the calculation of their designs upon this all-important principle. Having this, they need no laws of inverse squares of distances, no magnetic moments, none of the elaborate expressions for surface distribution of magnetism, none of the ancient paraphernalia of the last century. The simple law of the magnetic circuit, and a knowledge of the properties of iron, are practically all they need. About four years ago much was done by Mr. Gisbert Kapp, and by Drs. J. and E. Hopkinson in the application of these considerations to the design of dynamo machines, which previously had been a matter of empirical practice. To this end the formulæ of Prof. Forbes for calculating magnetic leakage, and the researches of Profs. Ayrton and Perry on magnetic shunts, contributed a not unimportant share. As the result of the advances made at that time, the subject of dynamo design was reduced to an exact science.

It is the aim and object of the present course of lectures to show how the same considerations which have been applied with such great success to the subject of the design of dynamo-electric machines may be applied to the study of the electromagnet. The theory and practice of the design and construction of electromagnets will thus be placed, once for all, upon a rational basis. Definite rules will be laid down for the guidance of the constructor, directing him as to the proper dimensions and form of iron to be chosen, and as to the proper size and amount of copper wire to be wound upon it in order to produce any desired result.

First, however, a historical account of the invention will be given, followed by a number of general considerations respecting the uses and forms of electromagnets. These will be followed by a discussion of the magnetic properties of iron and steel and other materials, some account being added of the methods used for determining the magnetic permeability of various brands of iron at different degrees of saturation. Tabular information is given as to the results found by different observers. In connection with the magnetic properties of iron the phenomenon of magnetic hysteresis is also described and discussed. The principle of the magnetic circuit is then discussed with numerical examples, and a number of experimental data respecting the performance of electromagnets are adduced, in particular those bearing upon the tractive power of electromagnets. The law of traction between an electromagnet and its armature is then laid down, followed by the rules for predetermining the iron cores and copper coils required to give any prescribed tractive force.

Then comes the extension of the calculation of the magnetic circuit to those cases where there is an air gap between the poles of the magnet and the armature; and where, in consequence, there is leakage of the magnetic lines from pole to pole. The rules for calculating the winding of the copper coils are stated, and the limiting relation between the magnetising power of the coil and the heating effect of the current in it is explained. After this comes a detailed discussion of the special varieties of form that must be given to electromagnets in order to adapt them to special services. Those which are designed for maximum traction, for quickest action, for longest range, for greatest economy when used in continuous daily service, for working in series with constant current, for use in parallel at constant pressure, and those for use with alternate currents, are separately considered.

Lastly, some account is given of the various forms of electromagnetic mechanism which have arisen in connection with the invention of the electromagnet. The plunger and coil is specially considered as constituting a species of electromagnet adapted for a long range of motion. Modes of mechanically securing long range for electromagnets, and of equalising their pull over the range of motion of the armature, are also described. The analogies between sundry electro-mechanical movements and the corresponding pieces of ordinary mechanism are traced out. The course is concluded by a consideration of the various modes of preventing or minimising the sparks which occur in the circuits in which electromagnets are used.

(*To be continued.*)

THE BRITISH ASSOCIATION AT LEEDS.

PRESIDENTIAL ADDRESS BY SIR FREDK. AUGUSTUS ABEL, C.B., D.C.L., D.Sc., F.R.S., &c.

(*Continued from page 204.*)

Such systematic researches as those upon which Osmond, Roberts-Austen, and many other workers have been for some time past engaged, may make us acquainted with the laws which govern the modifications effected in the physical characteristics of metals by alloying these with small proportions of other metals. The suggestion of Roberts-Austen, that such modifications may have direct connection with the periodic law of Mendeleeff, which may furnish explanations of the causes of specific variations in the properties of iron and steel, has been followed up energetically by Osmond, who has experimentally investigated the thermal

influence upon iron of the elements phosphorus, sulphur, arsenic, boron, silicium, nickel, manganese, chromium, copper, and tungsten. He regards his results as being quite confirmatory of the soundness of Roberts-Austen's suggestion, as they demonstrate that foreign elements having atomic volumes lower than iron tend to make it assume or preserve the particular molecular form in which it has itself the lowest atomic volume, while the converse is the case for the foreign elements of high atomic volume. An analogous influence was found to be exerted by those two groups of elements upon the permanent magnetisation of steel.

Captivating as such deductions are, those who have devoted much attention to the practical investigation of iron, steel, and other metals, cannot but feel that much caution has to be exercised in drawing broad conclusions from the results of such researches as these. Like the investigations recently made with the object of ascertaining the condition in which carbon exists in steel, and the part played by it in determining the modifications in the properties developed in that material by the influence of temperature and of work done upon it, they are surrounded by formidable difficulties arising from the practical impossibility of altogether eliminating the disturbing influences of minute quantities of foreign elementary bodies co-existing in the metal operated upon with those whose effects we desire to study. Certain it is, however, that by acquiring an accurate acquaintance with the composition of varieties of iron and steel exhibiting characteristic properties, by persevering in the all-important work of systematic practical examination of the mechanical and physical peculiarities developed in iron and steel of known composition by their association with one or more of the rarer metals in varied proportions, and by the further prosecution of chemical and physical research in such directions as those which have already been fruitful of most instructive results, such talented labourers as Chernoff, Osmond, Roberts-Austen, Barus and Stroudal, Hadfield, Keep, James Riley, Stead, Turner, and others, cannot fail to contribute continually to the development of improvements equalling in importance those already attained in the production, treatment, and methods of applying cast iron, malleable iron, and steel, or alloys equivalent to steel in their qualities.

The causes of the variations in the physical properties of steel produced by the so-called hardening, annealing, and tempering processes were for very many years a fruitful subject of experimental enquiry, as well as of theoretical speculation with regard to the condition in which the carbon is distributed in steel, according to whether the metal is hardened or annealed, or in an intermediate, tempered state. Recent researches have made our knowledge in the latter direction fairly precise; as yet, however, we are only on the track of definite information respecting the nature and extent of connection between the physical peculiarities of steel in those different conditions and the established differences in the form and manner in which the carbon is disseminated through it.

The careful systematic study of the modifications developed in certain physical properties of iron and steel by gradual changes of temperature between fusion of the metal and the normal temperature, has shown those modifications to be governed by a constant law, and that at certain critical temperatures special phenomena present themselves. This important subject, which was so clearly brought before the association last year in the interesting lecture of Roberts-Austen, has been and is still being pursued by accomplished workers, among whom the most prominent is F. Osmond. The phenomenon of recalescence, or the reglowing of, or liberation of heat in, iron and steel at certain stages during the cooling process, first noticed by Gore, and examined into by Barrett, appears to be the result of actual chemical combination between the metal and its contained carbon at the particular temperature attained at the time; while the absorption of heat, demonstrated by the arrest in rise of temperature during its continuous application to the metal, is ascribed to the elimination, within the mass, of carbon as an iron carbide perfectly stable at low temperatures. The pursuit of a well-devised system of experimental enquiry into this subject has led Osmond to propound theories of the hardening and tempering of steel which are at present receiving the careful study of physicists and chemists, and cannot fail to lead to further important advancement of our knowledge of the true nature of the influence of carbon upon the properties of iron.

Another important subject connected with the treatment of masses of steel, and with the influence exercised upon their physical characteristics by the processes of hardening and tempering, and by submitting them to oft-repeated concussions or vibrations, or frequent or long-continued strains, is the development and maintenance, or gradual disappearance, of internal stresses in the masses—one of the many important subjects to which attention was directed by Dr. Anderson, the Director-General of Ordnance Factories, in his very suggestive address to the Mechanical Section last year. This question is one of especial interest to the constructor of steel guns, as the powers of endurance of these do not simply depend upon the quality of the material composing them, but are very largely influenced by the treatment which it receives at the hands of the gunmaker. Indeed, the highest importance attaches to the processes which are applied to the preliminary preparation of the individual parts of which the gun is constructed, and to the putting together of these so as to ensure their being and remaining in the physical condition best calculated to assist each other in securing for the structure the power of so successfully resisting the heavy strains to which it has to be subjected, as to suffer little alteration other than that due to the superficial action of the highly-heated products of explosion of the charges fired in the gun. The development of internal strains in objects of steel, especially by the hardening and tempering processes, or by their exposure to conditions favourable to unequal cooling of different parts of the mass, has long been a subject of much trouble and of experimental enquiry in connection with many applications of steel. Systematic experiments of the kind commenced about 18 years ago by the late Russian general, Kalakoutsky, are now being pursued at Woolwich with the objects of determining the nature and causes of internal stresses in steel gun-hoops and tubes, and in shells, and of thereby establishing the proper course to be adopted for avoiding, lessening, or counteracting injurious stresses, on the one hand, and for setting up stresses beneficial to the powers of endurance of guns, on the other. One method of experiment pursued, with parts of guns, is to cut narrow hoops off the forgings, after a particular treatment, which are then cut right across at one place, it being observed whether, and to what extent, the resulting gaps open or close. This important subject has also been similarly investigated by my talented old friend and fellow-worker, the president this year of the Mechanical Section, Captain Andrew Noble, whose name in connection with the science and practice of artillery is familiar to us as household words.

The Crimean War taught nations many lessons of gravest import, to some of which Sir Richard Owen took occasion to call attention most impressively in the address delivered here, before the miseries of that war had become past history. The development of sanitary science, to which he especially referred, and which sprang from the bitter experience of that sad epoch, has had its parallel in the development of the science of artillery; but it would indeed be difficult to establish any parallelism between the benefits which even the soldier and the sailor have reaped from the great strides made by both these sciences. The acquisition of knowledge of the causes of the then hopelessness of gallant struggles which medical skill and self-sacrificing devotion made against the sufferings of the victims of battles and of fell diseases, as deadly as the cruellest implements of war; the application of that knowledge to the provision of the blessings of antiseptic treatment of wounds and to the intelligent utilisation of disinfectants and of other valuable preventive measures, to the supply of wholesome water, of wholesome food in campaigning, of sensible clothing, and of wholesome air in hospitals, barrack, and ships—these are some few of the benefits which the soldier and the sailor have derived from the development of sanitary science, which was so powerfully stimulated by the terrible lessons learned during the long-drawn-out siege of Sebastopol; and it is indeed pleasant to reflect that there has been for years past most wholesome competition between nations in the enlargement of those benefits and their dissemination among the men whose vocation it is to slay and be slain. The periodical International Congress, on Hygiene and Demography, of which we shall cordially welcome next year's assemblage in London, and whose members will deplore the absence from among them of the veteran Nestor in the science and practice of hygiene, Sir Edwin Chadwick, have afforded conclusive demonstration of the heartiness with which nations are now co-operating with a view to utilise the invaluable results attained by the successful labourers in sanitary science.

What, on the other hand, shall we say of the benefits which sailors and soldiers, in the pursuit of their calling, derive from the ceaseless costly competition amongst nations for supremacy in the possession of formidable artillery, violent explosives, quick-firing arms of deadly accuracy, and fearful engines which, unseen, can work wholesale destruction in a fleet? And what can we say of the benefits acquired by individual countries in return for their continuous, and sometimes ruinous, expenditure in endeavouring to maintain themselves upon an equality with their neighbours in man-killing power? The conditions under which engagements by sea or land will in the future be fought have certainly become greatly modified from those of 35 years ago, and the duration of warfare, even between nations in conflict who are on a fair equality of resources, must become reduced; but, as regards the results of a trial of strength between contending forces, similarly equipped, as they now will be, with the latest of modern appliances only varying in detail, these must, after all, depend, as of old, partly upon accident, favoured, perhaps, by a temporary superiority in equipment, partly upon the skill and military genius of individuals, and very much upon the characteristics of the men who fight the battles.

What really can be said in favour of the advances made in the appliances of war—and this is, perhaps, the view which in such a town as Leeds we should keep before our eyes to the exclusion of the dark side of the picture—is, that by continuous competition in the development of their magnitude, diversity, and perfection the resources of the manufacturer, the chemist, the engineer, the electrician, are taxed to the uttermost, with the very important, although incidental results, that industries are created, or expanded and perfected, trades maintained and developed, and new achievements accomplished in applied science, which in time beneficially affect the advance of peaceful arts and manufactures. In these ways the expenditure of a large proportion of a country's resources upon material which is destroyed in creating destruction does substantially benefit communities, and tends to the accomplishment of such material progress by a country as goes far to compensate its people for the sacrifices which they are called upon to incur for the maintenance of their dignity among nations.

From this point of view, at any rate, it may interest members of the British Association for the Advancement of Science, and for the promotion of its applications to the welfare and happiness of mankind, to hear something of recent advances in one of the several branches of science in its applications to naval and military requirements, with which, during a long and very arduous official career now approaching its close, I have become in some measure identified.

Since the meeting of the association in this town in 1858, the progress which has been made in the regulation of the explosive force of gunpowder, so as to adapt it to the safe development of very high energy in guns presenting great differences in regard to size and to the work which they have to perform, has been most important. The different forms of gunpowder which were applied to war purposes in this and other countries until within the last few years presented comparatively few differences in composition and methods of manufacture from each other, and from the gunpowder of our ancestors. The replacement of smoothbore guns by rifled artillery, which followed the Crimean War, and the great increase in the size and power of guns, necessitated by the application of armour to ships and forts, soon called, however, for the pursuit of investigations having for their object the attainment of means for variously modifying the action of fired gunpowder, so as to render it suitable for artillery of different calibres whose power could not be effectively, or, in some instances, safely, developed by the use of the only kind of gunpowder then employed in English artillery of all calibres.

The means resorted to in the earlier of these investigations, and adhered to for many years, for controlling the violence of explosion of gunpowder, consisted exclusively in modifying the size and form of the individual masses composing a charge, and of their density and hardness, with the object of varying the rate of burning of those masses in a gun, it being considered that as the proportions of ingredients generally employed very nearly correspond to those required for the development of the greatest chemical energy by the thoroughly incorporated materials, the attainment of the desired results should be, if possible, effected rather by modifications of the physical and mechanical characters of gunpowder than by variations of the proportions and chemical characters of its ingredients.

The varieties of powder from time to time introduced into artillery service as the outcome of investigations in this direction were of two distinct types. The first of these consisted of further developments of the old granulated or corned powder, being produced by breaking up more or less highly-pressed slabs of the material into grains, pebbles, or boulders of approximately uniform size and shape. Gunpowders of this class, ranging in size from about 1,000 pieces to the ounce to about six pieces to the pound, have performed efficient service, and certain of them are still employed. The character of the other type is based upon the theoretical view that uniformity in the action of a particular gunpowder, when employed under like conditions, demands not merely identity in regard to composition, but also identity in form, size, density, and structure of the individual masses of which a charge consists. To approach the practical realisation of this view, equal quantities of one and the same mixture of ingredients, presented in the form of powder of uniform fineness and dryness, must be submitted to a particular pressure for a fixed period in moulds of uniform size, the surrounding conditions and subsequent manufacturing processes being as nearly as possible alike. Practical experience has shown that uniformity in the ballistic properties of black powder can be even more readily secured by the thorough blending or mixing together of different products of manufacture, presenting some variations in regard to size, density, hardness, or other features, than by aiming at an approach to identity in the characters of the individual grains or masses.

When our attention was first actively directed to the modification of the ballistic properties of powder, the subject had already been to some extent dealt with, in the United States, by Rodman and Doremus, and the latter had proposed the employment, in heavy guns, of charges consisting of large pellets of prismatic form. While this prismatic powder, which was first used in Russia, was being perfected, and extensively applied there as well as in Germany and England, the production of powder masses more suitable, by the comparatively gradual nature of their explosion, for the very large charges required for the heavy artillery of the present day, was actively pursued in Italy, and by our own Government Committee on Explosives, the outcome of very exhaustive practical investigations being the very efficient Fossano powder, or *poudre progressif* of the Italians, and the boulder and large cylindrical powders produced at Waltham Abbey.

Researches carried out by Captain Noble and myself, some years ago, with a series of gunpowders, presenting considerable differences in composition, indicated that decided advantages might be secured, for heavy guns especially, by the employment of such a powder as would furnish a comparatively very large volume of gas, its explosion being at the same time attended by the development of much less heat than in the case of ordinary black powder. In the course of these researches much light was thrown upon the causes of the wearing or erosive action of powder explosions upon the inner surface of the gun, an action which, especially in the larger calibres of artillery, produces so serious a deterioration of the arm that the velocity of projection and accuracy of shooting suffer considerably, the wear being especially great where the products of explosion, while under the maximum pressure, can escape between the projectile and the bore. The great velocity with which the very highly-heated gaseous and liquid (fused solid) products of explosion sweep over the heated surface of the metal, gives rise to a displacement of the particles composing the surface of the bore, which increases in extent as the latter becomes roughened, and thus opposes greater resistance; at the same time, the high temperature to which the surface is raised reduces the rigidity of the metal, and its consequent power of resisting the force of the gaseous torrent; and, lastly, some amount of chemical action upon the metal, by certain of the highly-heated non-gaseous products of explosion, contributes towards an increase in the erosive effects. Experiments made upon a large scale by Captain Noble with powders of different composition, and with other explosives, have afforded decisive evidence that the explosive agent which furnishes the largest proportion of gaseous products, and the explosion of which is attended by the development of the smallest amount of heat, exerts least erosive action.

Some eminent German gunpowder manufacturers, who were at this time actively engaged upon the production of a suitable powder for heavy guns, directed their attention, not merely to an alteration of the proportions of the ingredients, but also to a modification in the character of charcoal employed; the eventual result was the production of a new prismatic powder, composed of saltpetre in somewhat higher proportion than in normal black powder, and of a very slightly-burned charcoal of reddish-brown colour, quite similar to the *charbon roux* which Violette produced about 40 years ago for use in sporting powder, by the action of superheated steam upon wood or other vegetable matter. This brown prismatic powder, or "cocoa powder," differs from black powder not merely in colour; it burns very slowly in the open air, and in guns its action is comparatively gradual and long-sustained. The products of its explosion are simple; as the powder contains saltpetre in large proportion relatively to the sulphur and charcoal, these become fully oxidised, and a relatively very large amount of water-vapour is produced, partly because of the comparatively high proportion of water in the finished powder, and partly from the large amount of hydrogen in the slightly-charred wood or straw used. The smoke from a charge of brown powder differs but little in volume from that of black powder, but it disperses much more rapidly, owing to the speedy absorption of the finely-divided potassium salts, forming the smoke, by the large proportion of water-vapour through which they are distributed.

This kind of powder has been substituted, with considerable advantage, for black powder in guns of comparatively large calibre, but it soon became desirable to attain even more gradual action in the case of the very large charges required for guns of the heaviest calibres, such as the 110-ton gun, from which shot of about 1,800lb. weight are propelled by a powder charge of 960lb. Brown powder has, therefore, been modified in composition to suit these conditions; while, on the other hand, a powder intermediate in rapidity of action between black powder and the brown prism powder has been found more suitable than the former for use in guns of moderately large calibre.

The importance which machine guns and comparatively large quick-firing guns have assumed in the armament of ships has made it very desirable to provide a powder for them which will produce comparatively little or no smoke, as their efficient employment becomes greatly limited when, after a very few rounds rapidly fired with black powder, the objects against which it is desired to direct the fire are more or less completely hidden by the interposed smoke. Hence much attention has of late been directed to the production of smokeless, or nearly smokeless, powders for naval use. At the same time the views of many military authorities regarding the importance of dispensing with smoke in engagements on land have also created a demand for smokeless powders suitable for field artillery and for small arms.

The properties of ammonium nitrate, of which the products of decomposition by heat are, in addition to water-vapour, entirely gaseous, have rendered it a tempting material to those who have striven to produce a smokeless powder; but its deliquescent character has been a formidable obstacle to its application as a component of a useful explosive agent. By incorporating charcoal and saltpetre in particular proportions with ammonium nitrate, F. Gaus recently claimed to have produced an explosive material free from the hygroscopic character common to other ammonium nitrate mixtures, and furnishing only permanently gaseous and volatile, or smokeless, products of explosion. These anticipations were not realised, but they led the talented German powder-maker, Mr. Heidemann, to produce an ammonium nitrate powder possessing remarkable ballistic properties, and producing comparatively little smoke, which speedily disperses. It yields a very much larger volume of gas and water-vapour than either black or brown powder, and is considerably slower in action than the latter; the charge required to produce equal ballistic results is less, while the chamber pressure developed is lower, and the pressures along the chase of the gun are higher, than with brown powder. No great tendency is exhibited by it to absorb moisture from an ordinarily dry, or even somewhat moist, atmosphere, but it rapidly absorbs water when the hygroscopic condition of the air approaches saturation, and this greatly restricts its use.

About five years ago reports began to reach us from France of the attainment of remarkable results with a smokeless powder employed with the repeating or magazine rifle then in course of adoption for military service, and of marvellous velocities obtained by the use of this powder, in specially constructed artillery of great length. As in the case of the explosive agent called *Mélinite*, the fabulously-destructive effects of which were much vaunted at about the same time, the secret of the nature of this smokeless powder was well preserved by the French authorities; it is now known, however, that more than one smokeless explosive has succeeded the original, and that the material at present in use with the Lebel repeating rifle belongs to a class of nitro-cellulose or nitro-cotton preparations, of which several have been made the subject of patents in England, and of which varieties are also being used in Germany and other countries.

A comparison between the chemical changes attending the burning or explosion of gunpowder, and of the class of nitro compounds represented by gun-cotton, at once explains the cause of the production of smoke by the former, and of smokelessness of the latter. Whilst the products of explosion of the nitro compounds consist

exclusively of gases and of water-vapour, gunpowder, being composed of a large proportion of saltpetre, or other metallic nitrate, mixed with charred vegetable matter and variable quantities of sulphur, furnishes products of which over 50 per cent. are not gaseous, even at high temperatures, and which are in part deposited as a fused solid—which constitutes the fouling in a firearm—and in part distributed in an extremely fine state of division through the gases and vapours developed by the explosion, thus giving to these the appearance of smoke as they escape into the air.

So far as smokelessness is concerned, no material can surpass gun-cotton (or other varieties of nitro-cellulose); but, even if the rate of combustion of the fibrous explosive in a firearm could be controlled with certainty and uniformity, its application as a safe propulsive agent is attended by so many difficulties that the non-success of the numerous early attempts to apply it to that purpose is not surprising. Those attempts, commencing soon after the discovery of gun-cotton, in 1846, and continued many years later in Austria, consisted entirely in varying the density and mechanical condition of employment of the gun-cotton fibre. No difficulty was experienced in thus exercising complete control over the rapidity of burning in the open air; but when the material was strongly confined, as in the bore of a gun, such methods of regulating its explosive force were quite unreliable, as some slight unforeseen variation in its compactness or in the amount and disposition of the air space in the mass, would develop very violent action. Much more promising results were subsequently obtained by me by reducing the fibre to a pulp, as in the ordinary process of making paper, and converting this into highly-compressed, homogeneous masses of the desired form and size. Some favourable results were obtained at Woolwich, in 1867-8, in field guns, with cartridges built up of compressed gun-cotton variously formed and arranged, with the object of regulating the rapidity of explosion of the charge. But although comparatively small charges often gave high velocities of projection, without any indications of injury to the gun, the uniform fulfilment of the conditions essential to safety proved to be beyond absolute control, even in guns of small calibre; and military authorities not being, in those days, alive to the advantages which might accrue from the employment of an entirely smokeless explosive in artillery, experiments in this direction were not persevered in. At the same time, considerable success attended the production of gun-cotton cartridges for sporting purposes, the rapidity of its explosion being controlled by various methods; very promising results were also attained with the Martini-Henry rifle and a lightly-compressed pulped gun-cotton charge, of pellet form, the uniform action of which was secured by simple means.

A nearly smokeless sporting powder had, in the meantime, been produced by Colonel Schultze, of the Prussian Artillery, from finely-divided wood, converted after purification into a mildly explosive form of nitro-cellulose, and impregnated with a small portion of an oxidising agent. Subsequently this powder was produced in a granular form, and rendered considerably more uniform in character, and less hygroscopic; it then closely resembled the well-known E.C. sporting powder, which consists of a nitro-cotton reduced to pulp, incorporated with the nitrates of potassium and barium, and converted into grains through the agency of a solvent and a binding material. Both these powders produce very little smoke compared with black powder, but do not compete with the latter in regard to accuracy of shooting, when used in military arms.

In past years both camphor and liquid solvents have been applied to the hardening of the surfaces of granulated or compressed masses of gun-cotton and of this class of its preparations, with a view to render them non-porous. In some smokeless powders of French, German, Belgian, and English manufacture, acetic ether and acetone have been also used, not merely to harden the granules or tablets of the explosive, but to convert the nitro-cellulose, in the first instance, into a more or less gelatinous condition, so that it can readily be incorporated with other components and rolled, or spread into sheets, or pressed into moulds, or squirted into wires, rods, or tubes, while still in a plastic state. When the solvent has afterwards been removed, the hardened, horn-like, or somewhat plastic product is cut up into tablets, or into strips or pieces of suitable dimensions, for conversion into charges or cartridges.

Another class of smokeless powder, similar in physical characteristics to these nitro-cellulose powders, but containing nitro-glycerine as an important component, has been originated by Mr. Alfred Nobel, the well-known inventor of dynamite, and bears resemblance in its physical characteristics to another of his inventions, called blasting gelatine, one of the most interesting of known violent explosive agents. When one of the lower products of nitration of cellulose is impregnated with the liquid explosive, nitro-glycerine, it gradually loses its fibrous nature, becoming gelatinised while assimilating the liquid; and the resulting product almost possesses the characters of a compound. This preparation, and certain modifications of it, have acquired high importance as blasting agents more powerful than dynamite, and possessed of the valuable property that their prolonged immersion in water does not separate from them any appreciable proportion of nitro-glycerine. The nitro-glycerine powder first produced by Mr. Nobel was almost perfectly smokeless and developed very high energy, accompanied by moderate pressures at the seat of the charge, but it possessed certain practical defects, which led to the development of several modifications of that explosive and various improvements in manufacture. The relative merits of this class of smokeless powder, and of various kinds of nitro-cellulose powder, are now under careful investigation in this and other countries, and several more or less formidable difficulties have been met with in their application, in small arms especially; these arise in part from the comparatively great heat they develop, which increases the erosive effects of the products of explosion, and in part from the more or less complete absence of solid products. The surfaces of the barrel and of the projectile being left clean, after the firing, are in a condition favourable to their close adhesion while the bullet is propelled along the bore, with the consequent establishment of very greatly-increased friction. The latter difficulty has been surmounted by more than one expedient, but always at the cost of absolute smokelessness.

Our knowledge of the results obtained in France and Germany with the use of smokeless powders in the new rifles and in artillery is somewhat limited. Our own experiments have demonstrated that satisfactory results are attainable with more than one variety of them, not only in the new repeating arm of our infantry, but also with our machine guns, with field artillery, and with the quick-firing guns of larger calibre which constitute an important feature in the armament of our Navy. The importance of ensuring that the powder shall not be liable to undergo chemical change detrimental to its efficiency or safety when stored in different localities where it may be subject to considerable variations of temperature (a condition especially essential in connection with our own naval and military service in all parts of the world), necessitates qualities not very easily secured in an explosive agent consisting mainly of the comparatively sensitive nitro compounds to which the chemist is limited in the production of a smokeless powder. It is possible, therefore, that the extent of use of such a material in our ships, or in our tropical possessions may have to be limited by the practicability of fulfilling certain special conditions essential to its storage without danger or possible deterioration. If, however, great advantages are likely to attend the employment of a smokeless explosive, at any rate for certain services, it will be well worth while to adopt such special arrangements as may be required for securing these without incurring special dangers. This may prove to be especially necessary in our ships of war, where temperatures so high as to be prejudicial even to ordinary black powder sometimes prevail in the magazines, consequent mainly upon the positions assigned to them in the ships, but which may be guarded against by measures not difficult of application.

The press accounts of the wonderful performances of the first smokeless powder adopted by the French—which, it should be added, were in some respects confirmed by official reports of officers who had witnessed experiments at a considerable distance—engendered a belief that a very great revolution in the conduct of campaigns must result from the introduction of such powders. It was even reported very positively that noiselessness was one of the important attributes of a smokeless powder, and highly-coloured comparisons have, in consequence, been drawn in Service periodicals, and even by some military authorities, between the battles of the past and those of the future, the terrific din caused by the firing of the many guns and the roar of infantry fire in heavy engagements, being supposed to be reduced to noise so slight that distant troops would fail to know in what direction their comrades were engaged, and that sentries and outposts would no longer be able to warn their comrades of the approaching foe by the discharge of their rifles. Military journals of renown, misled by such legendary accounts, chiefly emanating from France, referred to the absence of noise and smoke in battles as greatly enhancing the demands for skill and courage, and as surrounding a fight with mystery. The absence of recoil when a rifle was fired with smokeless powder was another of the marvels reported to attend the use of these new agents of warfare. It need scarcely be said that a closer acquaintance with them has dispelled the credit given to such of the accounts of their supposed qualities as were mythical, and a belief in which could only be ascribable to a phenomenal combination of credulity with ignorance of the most elementary scientific knowledge.

(To be continued.)

ON ALTERNATE CURRENTS IN PARALLEL CONDUCTORS OF HOMOGENEOUS OR HETEROGENEOUS SUBSTANCE.*

BY SIR WM. THOMSON.

This paper consists of a description of some of the results of a full mathematical investigation of the subject which I hope to communicate to the *Philosophical Magazine* for an early number.

1. Two or more straight parallel conductors, supposed, for simplicity, to be infinitely long, have alternating currents maintained in them by an alternate-current dynamo, or other electromotive agent applied to one set of their ends at so great a distance from the portion investigated, that in it the currents are not sensibly deviated from parallel straight lines. The other sets of ends may, indifferently in respect to our present problem, be either all connected together without resistance, or through resistances, or through electromotive agents. All that we are concerned with at present is that the conductors we consider form closed circuits, [illegible] one closed circuit, and that, therefore, the total quantities of el[illegible] tricity per unit of time at any instant traversing the n[illegible] sections in opposite directions are equal.

2. We suppose the period of the alternation to be ve[illegible] comparison with the time taken by light to traver[illegible] equal to the greatest diameter of cross-section of [illegible] curre[illegible]

* Paper read before the British Association.

The [illegible]

of conductors. This supposition is implied in the previous assumptions of parallel rectilinearity of the electric stream-lines, and of equality of the quantities of electricity traversing in opposite directions the several areas of a normal section.

3. We further suppose that the length of our conductors and their effective ohmic resistances are so moderate,* that the quantities of electricity deposited on and removed from their boundaries to supply the electrostatic forces along the conductors required for producing the alternations of the currents, are negligible in comparison with the total quantity flowing in either direction in the half period. This supposition excludes important practical

Fig. 1.

Fig. 2.

problems of telegraphy and telephony, the problem of long submarine cables, for instance, but it includes the problem of electric lighting by alternating currents transmitted at high tension through considerable distances, as, for example, from Deptford to London.

4. The general investigation includes as readily any number of separate circuits of parallel conductors as a single circuit, but for simplicity in describing results I suppose our system of conductors to be so joined at their ends as to constitute a single simple circuit of two parallel conductors.† It may be either two parallel conductors or one conductor, one of which may or may not surround the other, as shown in Figs. 1 and 2, representing cross-sections.

and uniformity of potential through A', even without the limitation of our subject laid down in Section 3.

7. The following are some of the most noteworthy results of the full mathematical treatment of the subject:

I. When the period of alternation is large in comparison with 400 times the square of the greatest thickness or diameter of any of the conductors, multiplied by its magnetic permeability, and divided by its electric resistivity, the current intensity is distributed through each conductor inversely as the electric resistivity; the phase of alternation of the current is the same as the phase of the E M.F., and the current across every infinitesimal area of the cross-section is calculated, according to the E.M.F. at each instant, by simple application of Ohm's law.

II. When the period is very small in comparison with 400 times the square of the smallest thickness or diameter of any of the conductors, multiplied by its magnetic permeability, and divided by its electric resistivity, the current is confined to an exceedingly thin surface stratum of the conductors. The thickness of this stratum is directly as the square root of the quotient of resistivity, divided by magnetic permeability of the substance in different parts of the surface. The total quantity of the current per unit breadth of the surface is independent of the material, and, except in such cases as those referred to at the end of II. below, varies in each cross-section in simple proportion to the electric surface density of the static electrification induced by the E.M.F. applied between the extremities for maintaining the current. The distribution of this electric density is similar in all cross-sections, but its absolute magnitude at corresponding points of the cross-section varies along the length of the conductor in simple proportion to the difference of electric potentials between A and A', and is zero at one end in the particular case in which the conductors are connected through zero resistance at one end while the E.M.F. is applied by an alternate-current dynamo at the other end. On the other hand, the surface distribution of electric current is uniform throughout the whole length of the conductors, and it is only its distribution in different parts of the cross-section that varies as the electric density.

The proportionality of surface intensity of the current to electric

Fig 3.

Each conductor may be single, as in Figs. 1 and 2, or either may be multiple parallels.

5. We suppose each conductor to be homogeneous in substance and in cross-section from end to end, but not necessarily homogeneous in different parts of the cross-section. Thus the two conductors, or the different parts of either, may be of different metals, or either conductor, or any part of either conductor, may consist of two metals (as iron and copper or iron and lead) laid parallel and soldered together.

6. We shall call A and A' the cross-sectional areas, or groups of areas of the two conductors, respectively, of the other. All the different portions of A are connected metallically at their two ends, and are thus all of them at one potential at one end and another potential at the other end, and similarly for A'. The homogeneousness of the material and of the cross-sections along the length of the conductors, and the uniformity of the total currents assumed in Section 3, implies that all the differents parts of A in one cross-sectional plane are at one potential, even though A consist of mutually isolated parts, or A' consist of mere isolated parts. If, as in Figs. 1 and 2, all the parts of A are in mutual metallic connection, and all parts of A' are in mutual metallic connection, this would entail uniformity of potential through A,

density, asserted above, fails clearly in any case in which the circumstances are such that the distance we must travel along the surface to find a sensible difference in electric density is not very great in comparison with the thickness of the current-stratum. Such a case is represented in Fig. 3, which is drawn to scale, for alternate currents of period $\frac{1}{80}$th of a second in round rods of copper of 6 cms. diameter. The spaces between the outer circular boundaries and the inner fine circles indicate what I have called the mhoic thickness,‡ being ·714 of a centimetre for copper of resistivity 1,611 square centimetres per second. The full solution for such a case as that represented in Fig. 3 belongs to the large class of cases intermediate between I. and II., and could only be arrived at by a kind of transcendent mathematics not hitherto worked. But without working it out it is easy to see how the time-maximum intensity of the current will diminish inwards from the surface, and will be at any point of either of the inner fine circles, about one-half or one-third of what it is at the nearest point of the boundary surface, and that at points in the surface, distant from B B' by one-half, or one or two times the mhoic thickness, the current intensity will be much smaller than it is at B B'.

III. In case I. the heat generated per unit of time, per unit of volume, in different parts of the conductors, is inversely as the electric resistivity of the substance, and directly as the square of

* The circumstances in which this condition is fulfilled may be usefully illustrated by considering the important practical cases of submarine cables, and of metallic circuits of two parallel wires insulated at a distance anything less than a few hundred times their diameter. For all these cases the numeric expressing the electrostatic capacity of either conductor (the other supposed for the moment to be at zero potential) is between 2 and 0·1, and for our present rough comparison may be regarded as moderate in comparison with unity. On this supposition the condition of the text requires for fulfilment that the mean proportion between the velocity which expresses in electromagnetic measure the resistance of one of the conductors, and the velocity of a body travelling the length of the conductor in a time equal to half the period of alternation shall be exceedingly small in comparison with the velocity of light.

† The case of a single circuit made up of parallel conductors, so joined at their ends that to travel once round it we must go and come two or three or more times along separate conductors, joined by their ends in series, so as to make one circuit, is specially considered in my paper on "Anti-Effective Copper in Parallel or in Coiled Conductors for Alternating Currents," to be communicated presently to Section A.

‡ Collected Papers, Vol. III., Art. CII., Sec. 35

the total strength of current at any instant. In case II. the time-average of the heat generated per unit of time, per unit of area of the current stratum, is as the time-average of the square of the quantity of current per unit breadth, multiplied by the square root of the product of the electric resistivity into the magnetic permeability.

IV. Example of III.—Let the conductor, A, be a thin flat bar, as shown in the diagram, Fig. 4, A' being a tube surrounding A, or another flat bar like A, or a conductor of any form whatever, pro-

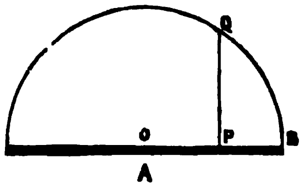


FIG. 4.

vided only that its shortest distance from A is a considerable multiple of the breadth of A. The thickness of A must be sufficiently great to satisfy the condition of II., and its breadth must be a large multiple of its thickness. (For copper carrying alternating currents of frequency 80 periods per second, these conditions will be practically fulfilled by a flat bar of 4 cms. thickness, and 30 or 40 cms. breadth). The current in it is chiefly confined to two strata extending to small distances inwards from its two sides. For copper and frequency 80 periods per second, the time-maximum of intensity of the current at the surface will be about ϵ^2, or 7·4, times what it is at a distance 1·43 cms. in from the surface. The quantity of current per unit breadth, or, as we may call it for brevity, the surface-density of the current in each stratum, is determined by the well-known solution of the problem of finding the surface electric density of an electrified ellipsoid of conductive material undisturbed by any other electrified body. The case we have to consider is that of an ellipsoid whose longest diameter is infinite, medium diameter the breath of our flat conductor, and least diameter infinitely small. In this case the electric density varies inversely as $\sqrt{(OB^2 - OP^2)}$. The graphic construction in the drawing shows $PQ = \sqrt{(OB^2 - PO^2)}$, and we conclude that the time-maximum of the surface density of the current varies inversely as PQ. The infinity which in the electric problem we find for electric density of the ideal conductor, is obviated for the electric current problem by the proper consideration of the rectangular corners, or the rounded edge (as the case may be), of our copper bar, which, though exceedingly interesting, is not included in the present communication. Suffice it to say, that there will be no infinities even if the corners be true mathematical angles.

V. Examples of cases I. and II.—Let A consist of three circular wires, C, L, and I, of copper, lead, and iron respectively. In case I., the quantities of the whole current they will carry, and the quantities of heat generated per unit of time in them, will be inversely as their resistivities. In case II., if the centres of the three circular cross-sections form an equilateral triangle, the quantities of heat generated in them will be directly as the square roots of the resistivities for C and L; and for I would be as the square root of the product of the resistivity into the magnetic permeability, if the magnetic permeability were constant and the viscous or frictional resistance to change of magnetism nothing for the iron in the actual circumstances. This last supposition is probably true, approximately, with a permeability of $\frac{1}{80}$th for iron or steel, according to Lord Rayleigh, if the current is so small that the greatest magnetising force acting on the iron is less than ·1 C.G.S.

VI. The dependence of the total quantity carried on extent of surface, according to the electrostatic problem described in II., justifies Snow Harris, and proves that those who condemned him out of Ohm's law were wrong, in respect to his advising tubes or broad plates for lightning conductors, but does not justify him in bringing them down in the interior of a ship (even through the powder magazine), instead of across the deck and down its sides, or from the masts along the rigging and down the sides to the water. The non-dependence of the total quantities of current on the material, whether iron or non-magnetic metals, seems quite in accordance with Dr. Oliver Lodge's experiments and doctrines regarding "alternative path" and lightning conductors. The case of alternate currents is, of course, not exactly that of lightning discharges, but from it, by Fourier's methods, we infer the main conclusions of II. and V., whether the discharges be oscillatory or non-oscillatory, provided only that it be as sudden as we have reason to believe lightning discharges are.

DISCUSSION.

Prof. Rowland said that he had considered these alternating currents in parallel conductors, and he believed he gave a theorem with regard to the distribution in the case of perfect conductors. He thought that that was the only case in which the problem could be solved. In that case the distribution was exactly the same as it would have been if they had been charged with electricity at rest, and there was some theorem, which he had almost forgotten now, with regard to the self-induction and the capacity. In that special case the self-inducting capacity. Of course, that was a much more limited problem than that Sir William Thomson had given, but he thought it led to interesting results. It guided them in their ideas with regard to the distribution, because in the case of perfect conductors the distribution of the current was exactly the same as the distribution of the density in the case of conductors at rest, so making the conductivity a little less than that; and they were guided to some extent by that theorem. But he did not know that any solution had ever been obtained in the case where the conductors were not perfect, and Sir William Thomson has found a solution of that nature.

COMPANIES' MEETINGS.

BRUSH ELECTRICAL ENGINEERING COMPANY.

The first annual general meeting of the shareholders in the Brush Electrical Engineering Company, Limited, was held on Monday at the Cannon-street Hotel, when the Right Hon. Lord Thurlow, F.R.S. (the chairman of the Company) occupied the chair.

The notice convening the meeting having been read by the secretary (Mr. E. Garcke),

The **Chairman** said: Gentlemen, as this is the first time I have had the honour of addressing you at an annual meeting of the Brush Electrical Engineering Company, perhaps you will pardon me if I say a few words in explanation of the position we at present occupy, and to describe the prospects and the financial and other results of the amalgamation. You will recollect that a statutory meeting of this Company was held on November 25th, and that on that occasion it was reported that the reconstruction and amalgamation of the Brush Company with the Australasian and other companies had been satisfactorily completed, and as we stand here to-day that position has assumed a practical reality. Then, as regards the reconstruction of the Anglo-American Brush Electric Light Corporation, I think little more can be told you than what you know. We have, of course, retained our works in Belvedere-road; in fact, we have retained everything that we possessed, and, in addition to that, we have acquired the valuable patents and the assets of which you are aware. New shares were issued, and the old shareholders got the new shares at the rate of two-thirds ordinary and one-third preference. As regards our new Falcon business at Loughborough, I will at a later stage give you a description of what those works consist. At the present time it will be sufficient to say that no time was lost in taking those works over, and that we immediately proceeded to spend what has turned out to be an amount of about £20,000 in erecting the new establishments to enable us to construct the heavy machines we are now being called upon to turn out. Then, as regards the Australasian Company, you will remember that the original scheme was that we should take over the entire business, their patent rights and stores, and issue to them £45,500 in shares and £500 in cash. The negotiations in connection with this matter were very protracted, not on account of any unwillingness on their part to enter into the arrangement, but because of the practical difficulty in assessing the value of the assets. However, those negotiations were satisfactorily concluded, but with a certain modification. The modification was that this Company, instead of taking over the stores, the floating assets, and the liabilities, took over only their patents and interest in the Melbourne Company, and agreed to issue £31,000 fully-paid up shares to them in the same proportion as was previously agreed upon. There were some subsequent negotiations following that, owing to the inability at the time of the Australasian Company to give a good title to everything that had been scheduled. The final result was that we took over their stores and their patents. The negotiations were difficult, but if it had not been for the conciliatory way in which we were met by Mr. Van Tromp, the chairman of the company, and the liquidators, I think the difficulty would have been so great that it might have fallen through altogether, and that, I think, would have been very regrettable. Then, although that is the final result at which we have arrived, negotiations are still taking place with a view to the Brush Company taking over the whole of their stores. From the first we have said that we would not take over their assets and liabilities, and from that position we have not departed; but in taking over their business in Australasia and other places, there is thus opened up for us an enormous field for business, and one which will require very considerable energy on our part to do it justice. To enable us to grasp more fully the position which the Board will occupy with regard to that part of the world, we requested Capt. Rowan, the very efficient manager of the company there, to come over here from Australia in order to advise us upon all points. He came here; we had lengthy meetings, and we entered fully into every point, and we finally made satisfactory arrangements by engaging him for a term of years. He has now gone out to take charge of our business, and to look after our interests. The final outcome of this amalgamation is as follows: we have issued to the Anglo-American Brush shareholders £156,942 of ordinary shares and £104,628 of preference shares; we have issued to the Falcon Company £33,305 in ordinary shares and £22,200 in preference shares, and we have issued to the Australasian Company £16,500 in ordinary and £11,000 in preference shares. The balance of the capital, which appears in the balance-sheet, is £24,192 in ordinary shares and £164 in preference shares. I think, when you look at the balance-sheet and see that on all these transactions we have only £256. 10s. in outstanding arrears, you will agree with me that the whole of the business has been satisfactorily carried out. These arrears, of course, are being collected and, in due course, they will, I think, disappear altogether. Then I come to the debentures. The debentures of £75,000 which the new Company issued could, of course, only be issued with the

consent of the debenture-holders of the original company. We had either to get their consent to convert their debentures into new debentures, or pay them off. The long and the short of it was that they met us in a friendly spirit, and they agreed, with the exception of £7,900 worth, to take the new debentures for the old. That amount of debentures had to be purchased by the liquidators of the old company, and they form a very valuable security for any shareholder who likes to get 6 per cent. for his money. I think it very desirable—for reasons that I need not go into—to keep these debentures amongst ourselves. For my own part, I intend to take up some, and I should strongly urge the shareholders of this Company to absorb these debentures. We will retain them in our hands for a limited time for that purpose. I should like to say a few words with regard to the general efficiency of the combined works which we now possess. The Brush Works are very satisfactory; the Falcon Works are extremely satisfactory, but the combination of the two for the carrying on of the electrical engineering business places us in an enviable position. The situation of these Falcon Works is everything that could be wished. It is just far enough out of London to enable us to obtain the cheapest, best, and most skilled of labour and the cheapest fuel. In addition to that, it is situated on one of the main lines of the railway system of this country, the Midland, bringing us in connection with the great arteries of the trade and commerce of Great Britain. We have a station at our doors, and sidings actually at our works, so that I think, from that point of view, the Falcon Works form an eminently satisfactory purchase. Of course, there are special kinds of machinery which we can manufacture more satisfactorily at Belvedere-road, but the heavy castings and the larger kinds of machinery we can make with very great advantage and on more favourable terms at the Falcon Works than we can elsewhere. The Falcon Works comprise about seven acres of ground, or about 35,646 square yards. That is many times larger than the works we have in Belvedere-road. Roughly speaking, about two-thirds of that space is covered by the old shops, and by those that we have subsequently built. I think it would be highly satisfactory to any shareholder who takes an interest in this business if he would take the time and the opportunity to go down there and look these things over for himself. I am sure that he will form a satisfactory opinion, and that he will come to the conclusion that the purchase is an eminently desirable one. The taking over of the Falcon Works places us in the position—in conjunction with the Belvedere-road Works—to manufacture and take the intermediate profits for that class of work which we were not able to manufacture before. The lifting power at the new works is all that could be desired – an important matter when we remember the heavy class of machinery we shall turn out there—some of the parts weighing 15 tons or more. The foundry, for instance, is fitted with a 15-ton overhead travelling crane. In those works, then, we shall be able to cope with work of almost any magnitude. I should like now to say a few words with regard to our expenses, and the profits earned. The profits we have earned appear, of course, in the balance-sheet, and you can therefore judge for yourselves. I would remind you, however, that you cannot very well compare the balance-sheet of this amalgamated company with the balance-sheet of the Brush Company that preceded it. You can, however, contrast the figures, and see, for instance, how the standing charges compare with those of the previous company. You will find that the standing charges have slightly increased, but that, I am bound to say, could not be otherwise when you consider the expenses of the amalgamation, and the taking over of these additional works at Loughborough, and other things. You will find, then, that they have increased from £11,131—I am speaking of the Brush standing charges of 1888—to about £16,000. I don't know that I can hold out very much hope of these standing charges being much reduced in the future. Of course, we shall do all we can in that direction, but I am bound to say that I do not hope they will be reduced, because as the business increases and extends, so also must the standing charges. There is no extravagance, nor even want of proper care and attention. It is one of the inseparable results of an extending business. As regards the liquidator's balance of £9,979, I think you may make your minds quite easy upon that. There is no loss upon that, because £7,900 of that amount is represented by the debentures of the old Brush Company which the liquidators have purchased. The balance consists of small debts and accounts, the bulk of which will be realised in due course. We have washed our hands of litigation pretty well, as you all know, and I think we are all thankful for that. The only remnant is the King-Brown action. You recollect that we had an action over the compound-winding machine. It was decided in our favour, and every manufacturer in England agreed to pay us a certain royalty. A firm in Edinburgh, however, thought it worth their while to have the action tried in the Scotch courts. It was tried in the courts of Edinburgh, and after a lengthy but not very costly litigation, it was decided against us. We appealed naturally to the Court of Sessions, and we lost the appeal. We then signified our intention of taking it to the highest court of appeal in the kingdom—the House of Lords. It will not involve any very great expense. I say we are bound to bring it to the final court of appeal for two reasons: in the first place, because the English courts of law gave a decision in our favour years ago, and, in the second place, because we wish to justify our position in having received these royalties from every maker in Great Britain for some years past. Of course, it is impossible to say what the decision may be, but if we gain the case, we shall continue in the receipt of these royalties, which form a valuable source of revenue. Then, with regard to the policy we have pursued in obtaining provisional orders. You know the Board of Trade granted provisional orders, and that after a certain lapse of time they had to be taken to Parliament, and you know also that many of the electric companies which are our competitors have largely applied for these orders. We, as a rule, have confined our applications to places where we had interests—to Bournemouth for instance, where we have large interests involved. We have, as a result of these applications, already acquired, as you know, the Bournemouth order and the order for lighting of a portion of the City. The City has been divided into three great districts, and we have obtained the central one. We have some months before us before we commence work, and that work is to be carried out in a period which will, we think, satisfactorily meet all the requirements of the case. The cost of carrying out the provisional order will amount to about £300,000. That is a very large item of business. You don't suppose that we are going to do all our business for nothing, and therefore that will prove a very valuable order indeed. We have at our Board, as you know, some of the most experienced men in electric lighting and engineering, and we shall spare no time or labour to carry out that order in such a way as will redound to the credit of this Company. I will only now, with your permission, say a few words about the dividend. You will see that the profit and loss account shows a gross profit of £36,698, and, after deducting all the standing charges, the cost of the maintenance of plant and buildings, and the interest on debentures, there remains a balance of £14,325. Of that it is proposed to write off £3,000 to the reduction of the property, patents and goodwill account, £625 for the reduction of the preliminary expenses, and £500 to the reduction of the provisional orders account. That, you will find, will leave a balance of £10,426 to appropriate. We have already made an interim dividend, absorbing £3,808. 6s. 10d., upon the preference shares for the six months from August 10th to February 10th last, and it is proposed to apply £3,505. 4s. 6d. to the payment of a further dividend upon these shares, making up the full preferential dividend at the rate of 6 per cent. per annum from the date of the registration of the Company to June 30, 1890. A balance of £2,796. 14s. 9d. will be available to carry forward to the next account. But though we have chosen to recommend the writing off of certain amounts, I hardly think myself that it is necessary to write them off. For instance, we are writing off an amount on account of suspense account and provisional orders. And you might not think it necessary in the first year of our existence to write off £3,000 from property account, or to write off a portion of our preliminary expenses, which only amount to £1,800. Although we recommend the writing off of these amounts, you are not compelled to do so, and you will find in that event £6,800 available for dividend on your ordinary shares. That would represent a dividend on only 11 months' working of 3 per cent., after paying the fixed dividend on the preference shares, the debenture charges, and other legitimate expenses. And when you take that into consideration, together with the profits accruing this year from the Australasian Company, that is not a very bad show for the first year of this Company. At the same time, we don't recommend you to take the dividend. We would rather you appropriated it in the way suggested in the balance-sheet. We feel sure that this is necessary if we are to occupy in the future a strong financial position as well as a strong acting position. Nobody can occupy a strong financial position in this city of London unless they act on certain well-known and recognised rules. One of our recognised rules is to write off on property and patents account as much as we can afford in the year, and also a portion of other charges which may be of an exceptional character. I say, then, that the line on which this balance-sheet has been drawn out and approved by our auditors, and on which the appropriation scheme has been made, is one of sound finance, and I think you will do very wisely in accepting it. There is another reason why we should occupy a strong financial position. We have this big City contract with £300,000 looming in the distance. That has to be got to do the work. We shall receive payments on account as the work may progress, but undoubtedly we cannot enter upon the carrying out of that contract without a certain amount of ready money in hand. Although we have now fair cash balances, a large amount on deposit and due to us, and everything in the most satisfactory shape, yet such a large contract as I have mentioned will very probably require some provision to be made for some extra financial assistance. That, at least, is my opinion to-day. I don't say it is absolutely necessary, or that it will be so; but, at any rate, you need not be surprised if we have to go before the shareholders or the public or the debenture-holders to receive any fresh money that may be required. And, if such an event should occur, it is necessary, of course, that our last balance-sheet should be thoroughly sound. For this reason I hope you will see your way to accede to the appropriation scheme we have drawn out in the balance-sheet for the past year.

Mr. B. H. Van Tromp seconded the motion. The Company, he said, was on the high road to being a very great success, and he had no doubt whatever that when the Directors met the shareholders again next year they would have a far better condition of things to place before them than had been the case that day. He had seen the works at Loughborough, and he did not hesitate to say that for the purpose for which they were designed there were few better works in England. There were appliances there which would enable them to do everything in connection with the utilisation of electricity as a motive power. They could turn out everything there—from the commonest piece of electric apparatus to an electric car or engine. There was nothing in the world that could be connected with electric traction that could not be made at Loughborough. The Chairman had omitted to say that in taking over the Australasian Company that Company had also secured the rights possessed by the former company in India. India, to the

mind of the speaker, offered a grand field for the future development of electric lighting. India was a country of luxury and wealth, and, possessed as it was of a very warm climate, electricity possessed a very great advantage over gas lighting. No allusion either had been made to the works of that Company in Vienna and Austro-Hungary. The Vienna works were being carried on at a considerable profit. The Directors were all anxious to make that a substantial dividend-earning Company. They would not be content simply with giving them a good dividend. Their desire in the future was to give them a very handsome dividend.

In answer to questions by Messrs. Flood, Smart, and Ward,

The **Chairman** stated that the relative cost of labour in London and Loughborough compared very much to the advantage of the latter. The salary account in the balance-sheet included everything except labour. Their new works at Loughborough were very advantageously situated for the construction of electric cars, and there was no doubt that when electric cars came to be utilised they would get their fair share of orders.

The report and balance-sheet were then put and unanimously adopted, and Messrs. Cooper Bros. and Co. having been re-elected as auditors, the proceedings closed.

CITY NOTES.

Commercial Cable Company.—The transfer books of this Company will be closed from September 20 to October 2 for the payment of the usual quarterly dividend of 1¼ per cent. on October 1.

Western and Brazilian Telegraph Company, Limited.—The receipts for the week ended September 5, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,590.

Brazilian Submarine Telegraph Company.—The receipts for the week ended September 5 amounted to £5.821.

Great Northern Telegraph Company.—The receipts for August were £25,000, making, from January 1, a total of £181,000, against £178,200 and £179,200 for 1889 and 1888.

NEW COMPANIES REGISTERED.

Freedman Battery Company, Limited.—Registered by Wm. Webb and Co., 6, Essex-street, Strand, W.C., with a capital of £2,000, in £1 shares; to acquire an electrical battery, particulars of which are not detailed, in accordance with an agreement made with Charles H. Freedman. The first Directors are Edward F. Wyman, Charles H. Freedman, and T. F. B. Evans. Qualification not specified. Remuneration to be determined in general meeting after declaration of 10 per cent. dividend.

PROVISIONAL PATENTS, 1890.

SEPTEMBER 1.

13735. **Improvements in apparatus for use in electro-metallurgical operations.** Carl Hoepfner, 45, Southampton-buildings, London.

SEPTEMBER 2.

13746. **Improvements in the manufacture of incandescent electric lamps.** Hannah Clegg, Brampton, West Norwood, Surrey.

13751. **Improvements in electric switches.** Charles William Huntington, 70, Market-street, Manchester. (Complete specification.)

13770. **Improvements in systems of electrical distribution of light and power by means of transformers.** William Frederick Taylor, Gilbert Betteley Luckhoff, and Emil Henry Hungerbühler, Woodlands, Harrow-on-the-Hill.

13774. **Improvements in electrical connections.** Frederick Charles Dunaway and Frederick William Dunaway, 23, Southampton-buildings, London.

13780. **Improvements in electric conduits.** William Robert Elliott, 323, High Holborn, London. (Complete specification.)

13790. **Improvements in conduits for electric conductors.** Henry Harris Lake, 45, Southampton-buildings, London. (Herbert N. Curtis, United States.) (Complete specification.)

13971. **Improvements relating to compositions and devices for use in the manufacture of filaments for incandescent electric lamps.** Henry Harris Lake, 45, Southampton-buildings, London. (Vincent Morgan Hobby, United States.) (Complete specification.)

13799. **Improvements in electrical signalling apparatus.** Henry Harris Lake, 45, Southampton-buildings, London. (Electric Secret Service Company, United States.) (Complete specification.)

13802. **Improvements in electrical measuring instruments.** George Washington Walker, 1, Queen Victoria-street, London. (Complete specification.)

13807. **An improved battery compound.** Charles Montgomery Reed, 4, South-street, Finsbury, London. (Complete specification.)

SEPTEMBER 3.

13838. **Improvements in automatic transmission through submarine cables.** John Gott and Thomas James Wilmot, 6, Lorna-road, Hove, Brighton.

13845. **Improvements in and relating to the propulsion of tramway vehicles or boats by means of electricity.** Joseph Leopold Huber and Louis Jones Magee, 45, Southampton-buildings, London.

13853. **Improvements in the production of electricity and in means or apparatus therefor.** Camille Alphonse Faure, 46, Lincoln's-inn-fields, London.

13855. **Improvements in electrical and other meters.** Louis Berdon, George W. Bousfield, and Francis Teague, 7, High-street, Hampstead.

SEPTEMBER 4.

13886. **Improvements in and connected with the distribution of power by alternating electric currents.** James Swinburne, Broom Hall Works, Teddington.

13897. **Improvements in apparatus for the safe deposit of milk and other articles; for electrically announcing the same, and for saving and registering time.** Cornelius Edward Kelway and Andeshir Kapadia, 71, Shardeloes-road, New Cross, London.

13905. **Improvements in and relating to the welding of metals by electricity.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

13906. **Improvements in and relating to the welding and brazing of metals by electricity.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

13921. **Improvements in electric lamps.** Alexander Schanschieff, 24, Southampton-buildings, London.

13943. **Improvements in power conduits for tramways or railways and in electrical connections therefor.** Carl Thomas Blanch Brain, 6, Lord-street, Liverpool.

SEPTEMBER 5.

13987. **An electricity counter.** Jules Richard, Felix Richard, and Georges Richard, 28, Southampton-buildings, London.

SEPTEMBER 6.

14050. **An improvement in electrical cut-outs.** Siemens Bros. and Co., Limited, 28, Southampton-buildings, Chancery-lane, London. (Siemens and Halske, Germany.)

14054. **Improvements relating to apparatus for converting alternating electric currents into continuous currents.** Walter Steadman, Richards and George Banker James, 45, Southampton-buildings, London.

14066. **An improved electric bolt lock.** Carl Popper, Temple chambers, London.

SPECIFICATIONS PUBLISHED.

1889.

12563. **Electrical ships' logs.** Lowne. 11d.
13273. **Arc lamps.** Julian. 6d.
14011. **Opening, etc., electrical circuits.** Shepard. 8d.
14377. **Electric lighting circuits.** Bradford. 1s. 1d.
15230. **Electric batteries.** Vavasour. 1s. 8d.
15246. **Regulating motor dynamos, etc.** Lahmeyer. 8d.
15402. **Electric distribution.** Thompson (Westinghouse). 8d.
15769. **Electric currents.** Thomson. 11d.
15936. **Cleaning electric lamps.** Robson. 8d.
15968. **Electric conductors.** Johnson and Phillips. 6d.
16697. **Electro-dynamic machines.** Bláthy. 11d.
17236. **Electric cables.** Heyl. 8d.
20797. **Electric light fittings.** Strode and Gill. 8d.

1890.

10593. **Electric motor apparatus.** Currie. 8d.
10712. **Electric lamp couplers.** Nichols. 6d.
11061. **Electric railway switches.** Lake (Swart). 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	1¾
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	8

NOTES.

Batley.—The electric light question is practically before the Town Council of Batley.

Newcastle Station.—Twenty-five feet high has been found the right height to erect the arc lamps at the Central Railway Station, Newcastle, instead of 17ft. as heretofore.

Ince.—The question of the lighting of Ince township, for which there have been several applications, is deferred until the termination of the proceedings with the Wigan Town Council.

Leamington.—The Lighting Committee at Leamington have obtained testing instruments, and are undertaking tests of the power of the electric lighting. The strength of the gas is 15·58 candles.

Birkenhead.—The Finance Committee have been appointed to carry out the provisional order for Birkenhead, as it was thought the proceedings of the Gas Committee might be regarded with disfavour.

Subway Construction in New York.—During the current year 158,180ft. of trench have been dug, and 774,930ft. of ducts laid, against 56,040ft. of trench and 621,430ft. of ducts in the whole of 1889.

Southend Pier.—A striking difference in the receipts is shown at Southend since the erection of the new pier with its electric railway. The receipts for August, from all sources, was £2,019 as against £726 for the month of August, 1888.

Telegraphy in Germany.—The Central Telegraph Office at Berlin has discontinued the use of batteries, and now obtains the power required for the working of the telegraphic service from an accumulator supplied by the Berlin Electric Light Works.

Canada and Bahama Cable.—Sir Ambrose Shea, governor of the Bahamas, had a conference with Sir John Macdonald regarding the establishing of a line of steamships between Canada and the West Indies, calling at the Bahamas, and also laying a cable from Nassam, Florida.

2,000-Volt Shock.—One of the workmen of the San Francisco Electrical Works accidentally received a shock of 2,000 volts direct from the dynamo. The man, who was at first thought to have been killed, recovered after a time. One of his hands is blistered, and he is suffering from soreness of the lungs.

Paper Insulation.—Now that insulation made of prepared fireproof papier-maché is coming into use for interior conduits in walls of houses, it may be well to mention that machines of new and improved construction are made by Eugène Defraiteur, of Verviers, Belgium, for making paper tubes.

Electric Hoists.—Electrical hoisting machinery is said to be giving great satisfaction on the piers of the Prentice Stores, in Brooklyn, New York. The motors there employed are of the Crocker and Curtis type, of 10 h.p. each, and automatically governed so that only enough current is used to lift the load on the ropes.

Bristol.—The sub-committee on electric lighting at Bristol, working in conjunction with Mr. Preece, have drawn up a report recommending a supply for certain of the principal streets, to be carried out by the Corporation. Fifty arc lamps of 1,200 c.p. are recommended to replace 170 gas lamps, the cost to be £25 per annum.

Electric Census Taking.—The electrical census tabulating machine, invented by Mr. Herman Hollerith, of Washington, U.S., has been a great success, and is enabling the authorities to deal with the large returns in a quick and clear manner. It is to be hoped that a similar arrangement will be adopted in our own approaching census.

Dover.—The establishment of a central station in Dover is now a question to receive a definite settlement. Their provisional order having passed, there is two years to put it into operation. At the Town Council meeting last week a committee was appointed to deal with the matter, and to investigate what had been done in other towns.

The Lighting of City Bridges.—It may be interesting to note that, according to the recently issued accounts of the City Corporation, the cost of gas for the lighting of the three bridges across the Thames within their boundary during the past year is as follows: London Bridge, £302; Blackfriars Bridge, £121; and Southwark Bridge, £107.

Bootle.—The Gas and Water Committee of the Bootle Town Council considered a report by the town clerk on the Birkenhead electric lighting order, and it was agreed that the Finance Committee be authorised to consider the provisions of the Birkenhead electric lighting order and to recommend what action, if any, should be taken in reference to it.

Haslingden.—It was decided at the monthly meeting of the Haslingden Local Board that the question of electric lighting should be adjourned for a month, and that in the meantime the clerk should obtain all the information he could as to the advantages of the electric light, the cost of laying down the system, and the steps which had been taken in other towns.

Pemberton.—By way of experiment, the Pemberton Local Board have accepted an offer from a firm of electricians to light about 400 yards of Ormskirk-road with one arc lamp and six incandescent lamps for two calendar months, at a cost of £20, the Board also providing the engine power and poles, and labour to assist in the fixing of the poles and wires.

Church Lighting at Brixton.—An installation of the electric light is at present being carried out at the Church and Parochial Hall of St. John's the Divine, Vassall-road, Brixton. About 300 incandescent lamps will be used. The plant consists of a gas engine, a dynamo, and a set of accumulators; a motor is also being put down for blowing the organ of the church electrically.

Peral Submarine Boats.—The Spanish Government has announced its intention not to construct any more of the Peral electric submarine boats. This, it is stated, is not because they are unsuccessful, but, on the contrary, because (the details of one part of the invention having been published) they do not wish the secrets of construction to leak out, therefore will not construct any more of the boats until any occasion arose by dispute with any other nation.

A Small Central Station.—The little French commune of Collias (Gard), a village of 645 inhabitants, about 11 miles from Nimes, has just obtained the luxury of electric light, which was inaugurated last week. It seems there is a small stream with a fall of 4ft., which produces an effective 9 h.p. This waterfall drives a small turbine, which runs a dynamo to supply 100 lamps of 10 or 16 c.p. The streets are lighted by 25 lamps of 16 c.p. The turbine runs till eleven o'clock in the evening, and during

the day time is also used to work force pumps, which supply Collias with water.

Alexite.—A new material for switches, under the name "Alexite," was shown by the Sawyer-Man Company at the grand convention of American electricians at Cape May. It is fire-proof, water-proof, and acid-proof; not fragile, highly durable, and can be moulded into any shape, but, besides this, it can be made to assume an infinite variety of shades and colours, imitating all known woods, marble and other polished stones so closely as to almost defy detection. For switch bases, cut-outs, roses, or exposed woodwork, this material seems to offer very decided advantages.

Cable Rates.—The Colonists want lower tariffs. The cable companies say: Pay us subsidies, and you can have lower tariffs. The Home Government and some of the Colonial Governments have had enough of subsidies, and refuse to pay more. Those who know best tell the cable companies they can lower their tariffs, maintain their lines, and still pay good dividends. The companies pretend to fear the recuperative power of lowering tariffs, and so time goes on. Our impression is that tariffs might be lowered without disadvantage to the companies, and with great benefit to business men who use the cables.

London-Paris Telephones.—At a meeting of the Hythe Town Council last week, a communication was read from the Secretary of the General Post Office, on behalf of the Postmaster-General, asking permission to erect telegraph posts and wires in certain thoroughfares of the borough. It was explained by the town clerk that he had been informed by the constructor of the telegraphs that a special wire for telephone business is to be carried from London to Hythe, and from Hythe under the Channel to Paris, so as to have direct telephonic communication between London and Paris. The Town Council gave the sanction asked for.

Electro-Gyroscopes.—M. Gustav Trouvé has communicated to the French Acadamie des Sciences an account of two forms of electro-gyroscope he has manufactured, the one to serve in demonstrating the movement of the earth, the other for the rectification of the mariner's compass. Both forms of the apparatus are illustrated in the current number of *L'Electricien*, page 844, and appear very workmanlike applications of the gyroscope in the directions indicated. The latter purpose possibly may be found a useful and almost necessary adjunct to the present binnacle in consideration of the extension of iron plates and the use of dynamos on shipboard.

Manchester-square Central Station.—We believe this station is just on completion, and at present they are running one 100-unit dynamo night and day. The plant now down is as follows: Ten 100-unit dynamos (Elwell-Parker alternators), 10 200-h.p. Willans high-speed engines, nine Babcock and Wilcox boilers. The dynamos are excited by four 7-unit exciters, driven by four 60-h.p. vertical engines. The machine-room is lighted up by eight Sunbeam lamps of 200 c.p., and several 16-c.p. lamps. There is to be a separate switchboard to each machine, comprising Cardew voltmeters, Elwell-Parker amperemeters, and the necessary switches.

Central Station for Southend.—At the meeting of the Southend Local Board last week, Mr. Hemmann moved that the Pier Committee be instructed to confer with Dr. Hopkinson and Messrs. Crompton and Co., with a view of ascertaining the advisability and the probable cost of extending the electric light to other parts of the town. The time had nearly arrived, he said, when the temporary arrangement of the electric works would be at an end, and permanent works would have to be taken in hand by Messrs. Crompton and Co., and he therefore thought this was the proper time to consider how far those works might be extended. The motion was put and carried, and it was also decided that Mr. Hemmann be invited to attend the meetings of the Pier Committee.

Bermudas.—The name of the Bermuda Islands was in every one's mouth a short while ago, and if any doubt was experienced by those weak in geography, the departure of the Guards to this spot would have assured them of the fact that it is a British possession. There is, if we are to believe a recent visitor, an admirable opening for the electric light in Bermuda, and the American companies have already been put on the track. Perhaps it will be worth while some of our own companies to take the hint and make enquiries. The Corporation of Hamilton is enterprising; the Government and military establishments might help; the Hamilton and the Princess Hotel would certainly entertain the idea, and the private persons and officials would be glad to get the cool and sweet light.

Stockholm Electric Lighting.—The following circular has been issued by the secretary of the Electrical Trades Section of the London Chamber of Commerce: "Having been advised that the notice which appeared in the electrical papers, that the date for the presentation of tenders for the lighting by electricity of the town of Stockholm had been extended from the 15th September to the 12th October, was erroneous, I have, at the request of the chairman of the Electrical Section, and after consultation with the Foreign Office and the Swedish Consul in London, communicated officially with the Stockholm Gas Works. In reply I have received official telegraphic intimation from that body, in language which is considered sufficiently satisfactory, that tenders for the electric lighting contract at Stockholm posted from this country not later than the 20th inst. will be considered."

Dublin.—A Local Government Board enquiry has been held at Dublin by Mr. C. P. Cotton, C.E., Chief Engineering Inspector to the Local Government Board, because of the Corporation's wish to borrow £63,000, the greater part of which—viz., £50,000—being required for electric lighting purposes. A license has been obtained, but it is not intended to light the whole city at once. The parts to be supplied by the proposed installation are Upper and Lower Sackville-streets, O'Connell Bridge, D'Olier-street, College-street, Westmoreland-street, College Green, Grafton-street, Dame-street, Parliament-street, Grattan Bridge, part of Capel-street, Mary-street, and Henry-street. The estimate for the work is about £37,000, so that power is asked for £13,000 more than is immediately required in view of extension. According to the evidence of Mr. Manville, electrical engineer to the Corporation, the work would be in going order in six months.

Partridges Struck by Lightning.—The German sporting paper, the *Waidmann*, contains the following account by a head gamekeeper in Prussian Silesia: "In mid-June an apprentice of mine found in the Briese shooting under my care a covey of partridges, two old birds and 15 young ones, all lying dead. The whole covey lay within a space of a square metre, with the heads together. As eight days elapsed before I received news of the discovery the birds were already too far gone for me to discover the reason for their death by examination of their bodies. I

suspected poison at first—the spot was close to some peasants' allotments—and caused the place to be carefully examined. In due course we discovered that the whole covey must have been struck by lightning. One could plainly see where the flash had struck a little mound, and from thence proceeded along the ground. The grass surrounding the spot where the partridges lay had a yellow and burnt appearance."

Barnsley.—The adoption of the Westinghouse tender for the Corporation central station in a somewhat sudden and unconsidered manner at Barnsley, has been the object of a great deal of keen feeling and animadversation in that town, and not only so, but some active measures have been taken to oppose the carrying out of the resolution. At the last meeting of the Lighting Committee the recommendation of the committee for the appointment of Mr. Bromley Holmes as electrical engineer during the construction of the plant, and for three months after its completion, was opposed by Mr. Bailey, who also went on to say that the Westinghouse tender was not the best that might have been adopted. On this latter point he was ruled out of order. Ultimately, he moved that the appointment of Mr. Holmes be referred back to the committee, and the minutes were carried subject to this provision. Mr. Bailey then gave notice that at the next meeting he would move that the resolution accepting the Westinghouse tender should be rescinded.

Barnsley Co-operative Society's Installation.—The installation set up by the Barnsley British Co-operative Society for the illumination of the whole of their central stores, reading-room, restaurant, etc., was run for the first time on Tuesday, and proved a great success. An engine and dynamo, capable of giving a total of 12,000 c.p., have been put down in a building newly erected for the purpose. The light is conducted all through the various buildings and 238 lamps of power varying from that of 16 candles to 100 candles are used for lighting them. The general opinion of the committee and members was that the installation was as great a success as the society's previous one at their corn mill. Messrs. Wilson Hartnell and Co., of Leeds, carried out the installation. The engine is by Messrs. Marshall and Sons, Gainsborough, driving a Crompton dynamo. The directors and others dined together at the Queen Hotel in honour of the event. The success of the installation is thought to be likely to have a favourable and stimulating effect upon the Corporation to carry out their own central station.

Storage Plant.—A plant of 264 Pumpelly cells, with 14 counter E.M.F. cells, has been installed by the Pumpelly Storage Battery Company, Chicago, at the new Edison substation in Detroit, where the current will be used in house lighting. The plant, in addition to the above number of cells, consists of two seven-point cut-out switches, five Andrew switches, three automatic switches, one gang switch, four ampere-meters and three rheostats. The cells are connected in three sets of 88 cells each, placed in series with independent discharge feeders; or they may be thrown into four sets of 66 cells each, placed in parallel, on each side of the main discharge circuit. During the short time the battery has been in use it has given good satisfaction, and enables the company to furnish current during entire 24 hours, though only operating the dynamos and engines about 10 hours per day. The cutting into circuit of either dynamos or batteries is instantly effected without a perceptible change in the lights. This is one of a number of plants, says the *Electrical World*, the Pumpelly Company has installed as aids to central station lighting.

Glasgow Tramways.—The question of tramways came before the Glasgow Town Council at their last meeting, and the minutes of the Tramways Committee, containing the detailed replies of counsel relative to the working of the tramways by the Corporation, were submitted. These opinions showed that there was no difficulty in the way of the Corporation if they chose to work the tramways themselves instead of renewing the lease. All their negotiations with the present tramway company for the renewal of the lease had so far come to nothing. In these circumstances the committee have been considering the advisability of working the tramways themselves, and they have appointed a special sub-committee to consider the desirability of applying for statutory powers to enable them to work the tramways by electricity, or other motive power than horses. The working of the tramways by the Corporation themselves would be a matter for the Council and the community to consider at a very early date. Mr. M'Kellar seconded the approval of the minutes, and suggested that they should use the Ibrox line, which they had lately acquired, for the purpose of experimenting with electricity. The minutes were adopted.

The Gordon Closed Conduit System.—We are pleased to believe from details put before us, that the Gordon closed conduit system for electric tramways is in a fair way of practical completion, and preliminary experiments are giving considerable confidence to the engineers of its success. Various modifications in the details have been made, as was to be expected, and these all tend to greater simplicity and handiness of an already simple system. The automatic chargers, which were to form part of the system, have been superseded by a very simple and effective long-pull magnet; the cables, or conductors, which are to go into the track are now made so that they can be threaded and dropped in or arranged without disturbing the track, and the disadvantage that was urged against the first plan, that two cars could not come within short distances so as to be "bunched" at a block, has been obviated by a slight alteration. We are given to understand that a large tram company, now employing steam engines, were about to abandon these and again take to horses, but have been induced, from having this system put before them, to continue until the Gordon car is running, when they will, if it prove successful, introduce the system for electric traction on their line.

Thomson-Houston Railway in Germany.—The first electric tramway in Europe, which was opened in Bremen on June 22 last, is thus described by *Kuhlow's Gazette*: The tramway commences in the centre of the town, near the town hall, passes by the new railway station, and finishes at Austellungs-platz, inside the entrance to the Bürger Park. The generating station is about 220 yards distant from this entrance. It contains a boiler constructed by the firm of Pétry-Déreux, a steam-engine of 150 i.h.p., made by Küchen, of Bielefeld, and a dynamo of 84 e.h.p., having a terminal pressure of 500 volts. The latter is driven by belting from the engine. In addition to these there is installed an Armington-Sims high-speed engine of 70 h.p., which actuates on an arc light dynamo used for lighting purposes only. Another dynamo of the same capacity as the first will shortly be laid down. This installation supplies current for—(1) the working of the electric tramway; (2) for the operation of a 15-h.p. motor

placed in the Vienna Bakery in Austellungs-platz, where the motor drives some kneading machines and an arc light dynamo for illuminating the buildings; (3) for the lighting of arc lamps and glow lamps arranged in series and installed on the Freien-platz; (4) for the illumination by means of glow lamps of that portion of the line from the railway viaduct to the park, and of several groups of glow lamps installed in two streets. The conductors are carried on insulators attached to the lower ends of short pieces of steel cable, the upper ends being fixed to steel and cast-iron standards. The conductors consist of copper wires 8·25 mm. thick. Under the railway viaduct they are carried only on insulators fixed to the arch of the viaduct.

The Sherrin Electrical Generator.—The following account of a primary battery and electric motor is from the *Times*; the technical press have not yet been invited. There is no reason why a primary battery should not drive a motor which should drive a Bath chair; the chief question is the expense of the zinc. It will be necessary to have an exact statement rather than an "estimate" before the scheme could be deemed at all practicable. The introduction of Prof. Thompson's name is only with regard to the efficiency of the motor. The account is as follows: A new form of electrical generator and motor have been invented by Mr. J. Vaughan-Sherrin, by means of which the propulsion of boats, tricycles, and Bath chairs is effected without accumulators. The generator is a two-fluid primary battery, in which the anodes are of zinc and the cathodes of carbon specially prepared. The depolarising liquid is a special composition which can be produced at a low cost; the zinc elements are immersed in plain water. The net cost of electric energy is estimated at from 9d. to 10d. per Board of Trade unit. The motor is a modified two-pole Gramme machine, having the field magnets constructed in a special manner. It can be driven in either direction with equal efficiency, and is remarkably free from sparking at the commutator. It is very light, a 1 horse-power motor weighing only 62lb., and it is well under control, being easily started, stopped, and reversed. It has been tested by Prof. Silvanus P. Thompson, and a half horse-power motor was found to give an efficiency of 65 per cent. It is stated that there is an entire absence of danger to those who are working the apparatus, as there is no chance of receiving a shock. We recently witnessed some trials with a tricycle, a Bath chair, and a 30ft. boat fitted with the Sherrin system. The trials took place at the offices of the Sherrin Electric Generator Company, 48, Eagle Wharf-road, London, and were very successful, as demonstrating the capabilities of both the generator and the motor.

Has the Dynamo Improved?—A correspondent, writing under the cognomen of "Volt Ampere" to the *Engineer*, seriously queries whether the modern types of dynamos have improved, or, indeed, are as good as, the old form of Gramme machine, and he gives his own experience as witness. He has for several years used two Gramme machines of 20 amperes and 60 volts, and, wanting more power, has put down two others of the most improved and modern kind, but can find no improvement in practice to his old ones. He wishes to know if dynamos have been really much improved by theory, and what he would gain by turning out his old Gramme machines and putting in new ones. He also makes some pertinent remarks about the commutator, which would seem now likely to be a common subject of discussion. "Have any of the makers of dynamos," he asks, "learned that the copper-mica commutator is a mechanical abomination? The upkeep of these things represents a considerable sum. They waste power and they waste electricity. They all spark and burn out themselves and the brushes. Some makers so construct their brushes that the sparking is hidden under the brush, but it goes on all the same. Can no one devise a machine in which rollers will be used instead of brushes; or, better still, one in which commutating will be effected inside the machine itself, instead of in the clumsy way now used? I am not an electrician, and perhaps I am a fool rushing in where angels—*i.e.*, electricians—fear to tread. If only the electricians had to pay for commutators as I have, I think they would scheme something better." He continues his query as to whether there has been any real improvement in the dynamo by relating that, while sticking to his two Grammes, he has allowed several persons to put down other dynamos at their own expense. Once an armature flew all over the place, and on another occasion he had a bundle of wires and a broken driving belt the next morning; and another burnt all the insulation off the field magnets. As for the old Gramme dynamos, "better they could not be, so far as trustworthiness is concerned."

Lighting of Fareham.—The town of Fareham was brilliantly lighted up by electricity on Thursday week, a banquet being held in honour of the occasion. A local company has been formed, and the installation has been carried out on the Thomson-Houston system by the Laing, Wharton, and Down Company. The banquet in honour of the inauguration was held in the Red Lion Hotel, Captain Ramsay, the chairman of the directors, being in the chair. Colonel Mumby, who was also present, heartily congratulated the company and the people of Fareham on being the pioneers of this light of the future so far as regarded this part of the country. He himself had been in a way connected with an electric light company, but the Corporation of Portsmouth had been pleased to take the matter into their own hands. He lived in hopes, however, that the Corporation might even yet transfer the business to them, and that they might be instrumental in introducing the light into Portsmouth. Mr. J. Graham Niven, in proposing the success of the electric light company, said that Fareham would be now only too proud to show to people from other parts of Hampshire and from other parts of England the results of a highly successful installation. He found in the town generally a feeling of confidence in the light. Mr. Blake, secretary to the company, stated that it had a capital of £5,000 in £1 shares, and had 60 shareholders with 3,900 shares taken up, and he had no doubt the remaining 1,100 would soon be taken up when it was seen that their efforts had proved successful. The Chairman gave the health of the contractors, who had been the means of lighting several towns. They had supplied the plant, and had treated the company with very great liberality, and had themselves taken a large number of shares in the company, which made its commencement possible. Unless they had been met in this way the company would have been unable to supply such a light to the people of Fareham. Mr. Wharton responded, and said his firm had taken shares in the company because they believed it to be a good speculation, and that it would be a good paying one. Englishmen, though progressive, were very slow to take up anything new, and they found great difficulty in introducing the electric light rapidly. In America there was scarcely a town of 20,000 inhabitants which had not the light, and he felt convinced that it would not be very long before this was the case in England.

TESTING THE FERRANTI MAINS.

Some miles of the Ferranti concentric mains that are to supply London on the high-pressure system from Deptford are, as we have already informed our readers, now laid. All these mains as they are laid have to be very carefully tested, as the enormous pressure used may be expected to be far different in its action to any other that has yet been employed in practical working. To test underground mains which are to work at a normal pressure of 10,000 volts is a matter requiring no little care and discrimination, and it can be well believed that such a ticklish matter as turning on a current which itself is sufficient to send a ⅜in. spark through air is one which does not come within the ken of many even of the most experienced of our present electrical engineers.

We have therefore thought that a description of the tests now being applied to the Ferranti mains will have an interest of a double value—first, as to the methods adopted for such an experiment in electric testing, and secondly, as to the results found and the differences experienced in dealing with such high potentials in long lengths of cable.

We must premise, in the first place, that anyone who expects delicate manipulation and elaborate mechanism either in the apparatus to be experimented upon or in the methods employed has but little understood the manner in which Mr. Ferranti has organised the lighting system from Deptford. We well remember asking Mr. Ferranti to explain the method upon which he tested the transformers and switches to be sent out for his high-tension system, and what instruments he used. "We couple two 10,000-volt transformers in series," he said, simply, "and connect up with the pressure of 20,000 volts. If there is anything left it is passed as good." The explanation, if a little off-hand, serves very well to indicate the kind of testing that has to be dealt with in the whole system. One other illustration will serve to indicate the way in which the problems as they arose have been tackled. A certain electrical engineer, himself well enough known both in cable and in alternate-current work remarked that one point over which Mr. Ferranti might be expected to experience great difficulty was the arrangement of the expansion-joints, evidently figuring a complicated arrangement of sliding contacts. In reality, the device adopted in the Ferranti system as expansion-joint is nothing more complicated than one length of the main, bent by a rail-bending machine into a long S form, the expansion serving simply slightly to increase the bend.

At the present time there is a total of 21 miles of the main laid and jointed along the route from Deptford to London. These are to form four parallel mains from Deptford. None of them are yet in one length, but are being connected together as fast as the curves across the railway bridges can be laid. The mains are laid mostly four in one trench, and the line is complete from the Charing Cross end to the Grosvenor in Bond-street.

The London Electric Company have obtained a site in Red Lion-yard, Cockspur-street, and it is to this place that the ends of the cables are led, and here they have been tested day by day as the lengths are connected on. This station we have had, through the kindness of the company's engineers, the opportunity of inspecting while the tests alluded to were being carried on, and these tests we now propose to describe.

Tests in Laying.

In the first place, all lengths of concentric main are tested as they come from manufacture at Deptford. We fully described the manufacture of the mains in our issue of June 20th last, and it will be only necessary to say here that the mains each consist of two concentric lengths of thick copper tube run one inside the other, separated by a special insulation of waxed paper and shielded on the outside by a steel sheath, also separated from the outer conductor by a thinner insulation. The mains are manufactured in 20ft. lengths, each main being coned or tapered down at one end and similarly bored out at the other, so that they can be pressed together when slightly heated, and the joint becomes a solid mass. So much is this so that when occasion arises to break the joint, the material often prefers to break clean across than to separate along the coned surfaces. These 20ft. lengths are tested at Red Lion-yard, 10 being connected in parallel, with a pressure of 20,000 volts in the manner to be presently described, and it is a remarkable and noteworthy fact, as stated by the engineers, that although many hundreds of these lengths have been so tested not a single one has yet broken down or any way failed.

The mains are next laid in the street, trenches are dug, thin boards, well creosoted or pitched, are formed into a trough, and the mains, which are to some extent flexible, are laid therein, bitumen is poured over them, the top board is put on, and then a layer of asphalte is poured on top of the board, thus forming a most efficient protection against injury by a pick or other tool, and then the earth is covered in. As each length is laid and the joint is finished, the conductors are tested for continuity. It would be a little bewildering to one who knew somewhat but not quite enough about this testing to see 10,000-volt mains tested with a simple four-volt cell and detector. The next test is that of outer conductor to sheathing. This is first done with an eight-cell battery and a sensitive pivoted galvanometer to make sure of no accidental circuit. The work of laying then proceeds until the evening, or until such time as a high-volt test is to be made. For this purpose the whole of the various mains are connected up in series, so as to make simply one long length to be tested, the ends being already within the station at Red Lion-yard. For the 10,000-volt test it is sufficient if at the further end the two adjacent cables be connected together—inner to inner and outer to outer—by two ordinary highly-insulated cables laying along the trench in the roadway, and this method is adopted when the two cables have not both exactly the same length laid, and therefore do not finish quite at the same place. But for the 20,000-volt current to be put on requires both cables to be finished to the same point, and connected across by a piece of the true Ferranti main, otherwise sparking or other effects occur on the cable along the trench. When properly connected, the mains are first generally tested with a 100-volt current to make sure the insulation has no accidental small fault, and then the 10,000-volt current is turned on.

Novel Phenomena.

Here we must allude to a phenomenon which has not yet come beneath the notice of electrical engineers. In any electrical transformation at ordinary pressures, the transformed current comes out at a pressure of the ratio of the transformer used, or, indeed, slightly less, due to loss in the transformer. Curiously enough—a matter of considerable importance to alternate-current engineers—this is by no means always the case when the alternate current is of high pressure—that is, of the nature of 10,000 or 20,000 volts, combined with a concentric cable. When a length of concentric main is connected thereto, it acts in the manner of a condenser, and a certain quantity of the current is required to charge the mains themselves, and the pressure on the mains in a long length seems to "pump up," as it were, and add together, so that the pressure on the other side of the transformer is far higher than the ratio would seem to indicate. Thus a transformation which would give 20,000 volts on a short length, if applied to a fairly long length of some miles, the pressure may rise to 25,000 or even 30,000 volts, and possibly to a far higher point. It was evident at an early stage that other effects than those generally experienced had to be dealt with, as in testing, if the length were long, the fuse which connects the main was found to give way at once with the sudden rush of current required to charge the conductor. For example, when the mains were laid to Blackfriars the four sets were connected all in series as before mentioned, and the 20,000-volt current was turned on. At once the fuse connecting them went. Another fuse was put in and again went, and so on, until the mains were disconnected, and one length only was connected when (the charge for the length being less) the fuse stood, and no bad effect was observed. It has been found necessary, therefore, to always connect transformers at the further end and draw off some current—in other words, always to have some load on the main. This is necessary

both on account of the precaution, and also as it is otherwise impossible to judge how far the pressure actually does rise in the mains. Even in this case, and when running some score or two of lamps, the potential, which at the generating end would be normal (say, 2,500 volts transformed up to 10,000), has shown up to 160 volts on the lamp circuit when transformed down again, instead of 100 volts, thus indicating the pressure in the charged length of main to be raised to 160 × 24 × 4 = 15,360 volts, instead of the original 10,000 volts. This result is sufficiently remarkable, and will, no doubt, be the occasion of much speculation and observation by electrical engineers.

In practice the dynamo would be run slower, or the exciting current used would be less to obtain the 10,000-volt pressure desired. It is not yet definitely known whether this high pressure has the power of self-regulation to one uniform pressure in the whole main, or whether there is still a certain fall of pressure over a long length of main due to the ohmic resistance, as would, of course, have been expected were it not for the new conditions which obviously rule as shown in the rise in pressure we have described.

Testing With 10,000 Volts.

The diagram given herewith shows the method of connection for the testing of the mains when laid with the 10,000-volt pressure. The ordinary mains from the Grosvenor are led in at 2,400 volts. From these, wires are taken, passing each through two long high-pressure fuses, and then by a double-pole switch to two 10,000-volt transformers connected in parallel. These transformers have a ratio of four to one, so that the exact pressure on the terminals is 9,600 volts. The Ferranti mains end, as we have seen, in a cone, the inner conductor projecting forward. In the tests which we witnessed on August 30th, the four lengths of underground main were previously connected in series, as shown, so as to make one length of about one and a half miles, commencing at the testing station, going down to Brewer's-lane, Charing Cross, returning to Piccadilly-circus, doubling back to Brewer's-lane, and so returning to the testing station at Red Lion-yard. The wires at 9,600 volts were led to one end, and connected to the inner and outer conductors, so that the whole length had this pressure between its two concentric tubes. The circuit finished at the end of the second main at the testing station, and from there was led off to a discharging arrangement. This is shown in diagram in the figure, and consists of four sets of small transformers, ratio 24 to 1, connected two in parallel and the four sets in series, thus reducing the pressure again to (9,600 ÷ 4 × 24) a nominal 100 volts. The current was taken off each transformer separately by four 100-c.p. lamps, or eight 50-c.p., as the case may be, each transformer thus giving 15 amperes, or each set of two, 30 amperes. As the ratio of reduction is practically 1 to 100, the current in the 10,000-volt main was about 0·3 ampere only. When the current was turned on, as a matter of fact the lamps were consideraby over-incandesced, and the Cardew voltmeter which was connected to the lamp circuit indicated 110 volts. When only one set of transformers is attached to discharge the mains, the pressure has been seen to rise to 130 volts on the voltmeter, and with a longer length of main even to 160 volts.

The above is a statement of the arrangement for testing adopted on our visit. The current was kept on some minutes, and then the fuse went. This was owing to the fact that three strands of fuse only had been used to charge the mains for some time. New lengths of main had been added, and this, as we have said, causes the rush of current to be greater as the length increases, due to the condenser action of the main, the greater current reappearing in increased electrical pressure. Four strands of fuse were inserted, and then the 10,000-volt current was kept for some quarter of an hour or so upon the 1½ miles of newly-laid main.

The tests with 20,000-volt current were not taken at the time of our visit, but it is easy to see the arrangement adopted. The two first transformers in this case are connected in series instead of in parallel, as shown, and the discharging transformers are also connected all in series. This higher test cannot always be taken, as the mains must be closely connected (as already mentioned) with concentric main at the ends. The distance between the inner conductor and the copper sleeve projecting from the outer conductor is only ⅛in. through air, and over this distance on damp days the 20,000-volt current will spark across with loud cracks like a pistol report. This highest potential is therefore not always employed, but the main has been repeatedly tested under this enormous pressure on many occasions.

After the main insulation has been tested, the insulation between outer conductor and the steel sheathing is tested in a similar way with transformers at a pressure of 500 volts, a discharging transformer being connected at the further end as before, the current in this case being absorbed by a metal resistance.

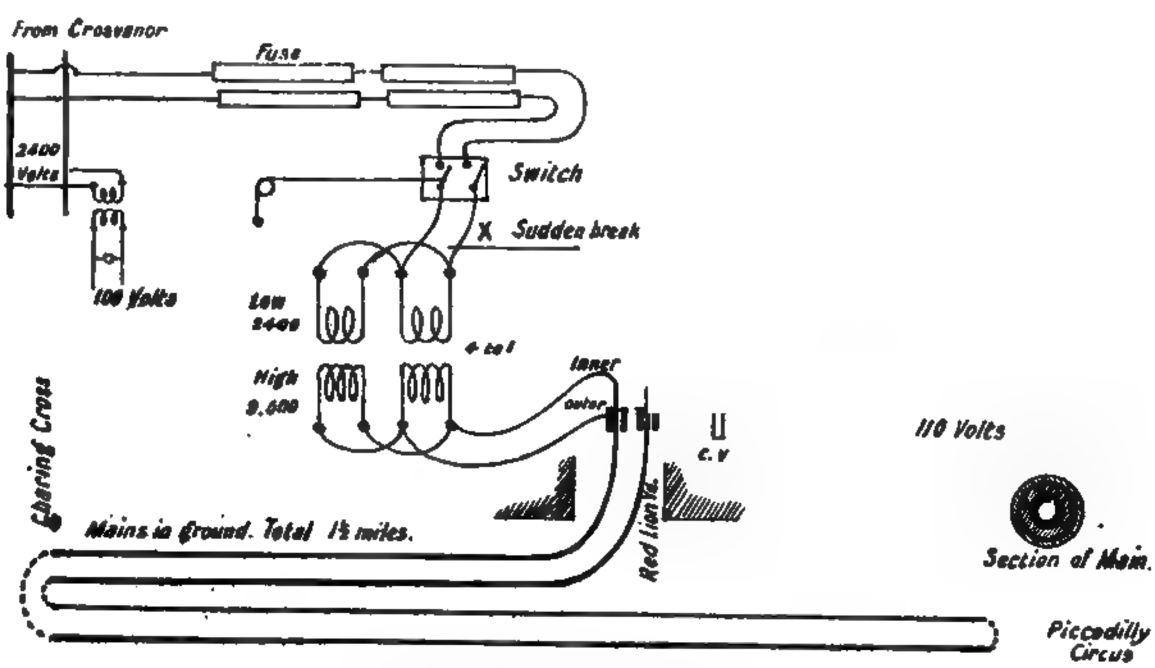


Diagram of Testing Ferranti 10,000-Volt Mains.

Progress of the Work.

The work of laying the mains is now progressing rapidly. The four sets of main are practically complete to London Bridge; three sets are complete across the Charing Cross railway bridge. The mains are also laid as far as the Grosvenor Gallery. Some 13 gangs of men in all are working at them, and 21 jointing apparatuses are in use. The following is the list of the gangs at work to Aug. 30th,

1. Along South-Eastern Railway	These two are suspended mains.		
2. Over Charing Cross railway bridge			
3. Under Spa-road railway station	Underground	Ferranti main.	
4. Snow Fields, London Bridge	”	”	
5 and 6. Blackfriars distributing station	”	”	
7. Belvedere-road, Lambeth	”	”	
8. Strand	”	”	
9. Piccadilly-circus	”	”	
10. Clifford-street, Bond-street (towards the Grosvenor Gallery)	”	”	
11. Park-lane	Silvertown main,		2,400 volts.
12. Along Piccadilly	”	”	
13. Along Parliament-st., Westminster	Siemens main.	”	

The above will show the nature of the progress made in the laying of the mains. Meanwhile, we may say that during the week ending August 30th the Deptford station ran the whole of the load of 38,000 lights without any assistance from the Grosvenor, by the present temporary cables at 5,000 volts, continuously without stopping from the Monday morning till the Saturday night. The opportunity has been taken to make some interesting experiments with the Grosvenor dynamos, such as running them in parallel, and running them as motors from each other, and from Deptford. It is interesting to state that the Grosvenor dynamo has run as a motor, turning itself, and running the engine, with an expenditure of energy calculated from the current and pressure readings of 50 h.p. Since this date the two dynamos at the Grosvenor have supplied the circuits in parallel. We may expect to hear further interesting details of these experiments; meanwhile, the description of the tests we have been able to lay before our readers will give subject for ample consideration and reflection.

THE EDINBURGH EXHIBITION.—XVI.

Stand No. 33. Sir William Thomson's Instruments.

(Continued from page 212.)

The magneto-static current meter, Fig. 1, consists essentially of a small steel magnet or system of magnets suspended in the centre of a uniform field of force due to two coils, each having one or more turns of copper ribbon or wire, and also under the directive influence of two systems of powerful steel magnets.

The suspended system of magnets is attached to one end of a vertical shaft passing down centrally through an opening in the sole-plate of the instrument from an indicating needle which is supported by a jewelled cap resting upon an iridium point.

The two systems of directive magnets are circular in form, and each ring is composed of two semi-circular magnets placed in a brass cylindrical frame with their similar poles together. Each system is securely fixed to a circular brass frame, which fits on to the cylindrical case of the instrument in such a manner that the systems are capable of being turned round, together or separately.

The instrument has a "tangent scale," which is adjusted in its position before the instrument is sent out, so that the needle indicates equal differences of readings for equal differences of current. The scale consists of a hundred divisions, and for most purposes it is convenient to set the field magnets in such a position that the needle points to 0, and to use the scale from that point upwards towards 100. Sometimes, however, it may be found convenient to measure currents, whose direction is being occasionally reversed, without being at the trouble of reversing the electrodes in the contact clip; in that case the zero should be set to the division 50 at the middle of the scale, and readings taken on each side of it. It must be remembered that when the point taken as zero is changed, the constant, by which the indications of the instrument have to be multiplied to give the current in amperes, is changed in proportion to the cosine of the angle between the zero point and the middle of the scale; and as this angle is 60deg., the constant with the zero at 50 on the scale is exactly double the constant with the zero at 0 on the scale.

The instrument is provided with a "lifter," which serves to raise the needle off the iridium point when it is being moved about from place to place. This lifter is in the form of a ring placed below the needle, and may be raised or lowered by turning the handle attached to an eccentric passing through the side of the instrument on a level with the scale. It also serves as a checker, by bringing it lightly into contact with the pointer, so as to stop its vibrations.

The two grades of this instrument which are found most convenient are:

The milliampere-meter, which has an effective range of from ·3 to 300 milliamperes, and is usually adjusted to read two milliamperes per division.

The ampere-meter, which has an effective range of from ·3 to 300 amperes, and is usually adjusted to read one ampere per division; in both grades with the zero at 0 on the scale. If desired, instruments can be supplied having the constants adjusted to any value. The very wide range of accurate measurement given by these instruments makes them invaluable for laboratory use.

The instrument has an advantage, important for some practical purposes, of being available as an accurate direct-reading current meter, through a continuous range of from 1 to 100 times its smallest current, which may be anything from half a milliampere to four amperes, according to the number of turns in the coils supplied with the instrument.

Fig. 1.

It is not, however, available as an alternate current instrument, and it must be remembered that the magnetism of the steel directing magnet does not remain absolutely constant. With good quality of steel a proper preliminary ageing of the magnet (by heating it several times in boiling water and cooling it again, and subjecting it to somewhat varied rough usage) brings it to a condition in which its magnetism is found to remain exceedingly nearly constant month after month and year after year. Still, it should never be relied upon as absolutely constant, and for accurate laboratory work it is therefore necessary to have some means of retesting the instrument at any time. This is always easily done with the utmost accuracy if one of the balance instruments is available as a standard.

Another advantage which the instrument has is that, when a standard instrument is available, its constant is capable of being varied to any desired value down to one-tenth of that which it has with its directive magnets in their strongest position. Thus, if the constant should be three amperes per division of the scale, with the similar poles of the magnets coinciding, it may be adjusted to any value down to 0·3 ampere per division.

One very convenient use of the instrument is to act as a lamp-counter for indicating the number of incandescent

lamps in use in an installation. For this purpose it is best to standardise it by putting on a known number of lamps and adjusting as described below until the desired reading is obtained on the scale. Of course, this numbering of lamps is not possible to any great accuracy, because the lamps themselves are not rigorously equal in the amount of current which each takes, but the lamp-counter serves the important practical purpose of showing at any time the number of lamps in use nearly enough for practical purposes. In private houses this is very useful as a check against some lamp or lamps being left accidentally alight in a cellar, or safe-room, or box-room, or other place where the fact of its being alight might escape observation for days or weeks together.

To count larger numbers of incandescent lamps up to 1,000 or more, the instrument is made with smaller rings of more massive conductor, and the same proportionate accuracy is attained as with the 100 lamp-counter.

The milliampere-meter, on account of the low resistance of its copper coil—about 40 ohms—may conveniently be used as a voltmeter. To adapt it for this purpose a copper cylinder, wound anti-inductively with two platinoid resistances, is supplied. The first of these, together with the resistance of the instrument, makes up 100 ohms, and the second alone is 900 ohms. Thus, taking the constant of the instrument at two milliamperes per division, by joining the smaller in series with the instrument, the reading on the scale will be 1·5 of a volt per division; with both resistances in series with the instrument the reading will be two volts per division.

ON THE CHARACTER OF STEEL USED FOR PERMANENT MAGNETS.*

BY W. H. PREECE, F.R.S.

In the discussion which followed the reading of Dr. John Hopkinson's presidential address to the Institution of Electrical Engineers, I took the opportunity to point out that the quality of magnetic steel in England had deteriorated, and that it was not to be compared with that produced in France in 1881. This statement was questioned at the time, and I determined to make an exhaustive test of the various steels that are now in the market. Specimens were therefore obtained from the leading firms in Shef-

* Paper read before the British Association.

TABLE I.—Results of Experiments for Determining the Magnetic Moments, etc., of Various Kinds of Steel.

First Series.—June, 1890.

Name of manufacturer.	No. of specimen.	Weight.	Mean area of poles.	Length.	Volume.	Mean moment M.	Specific magnetism.	Intensity of magnetisation (I).	Induction (4πI) B.	Mean induction of specimens made from each kind of steel.	Remarks.
		Gra'mes	Sq. cm.	Cm.	Cub. cm.						
Wall	1	67·279	·8503	10·025	8·525	985·4	14·65	115·6	1452	1524	Steel splits in tempering.
	2	67·235	·8513	10·04	8·547	962·0	14·31	112·6	1414		
	3	66·252	·8446	10·02	8·463	1032·5	15·58	120·8	1517		
	4	66·648	·8487	10·01	8·496	1158·5	17·38	136·4	1713		
Ashforth	1	75·228	·9295	10·00	9·295	1380·5	18·35	148·5	1866	1710	
	2	76·265	·9436	10·00	9·436	1274·5	16·71	135·1	1697		
	3	75·870	·9365	10·00	9·365	1101·5	14·52	117·6	1478		
	4	76·247	·9398	10·03	9·426	1348·8	17·69	143·1	1798		
Saunderson	1	77·962	·9712	10·04	9·750	1258·4	16·14	129·1	1622	1444	One specimen split slightly in tempering.
	2	77·800	·9740	10·03	9·770	1051·0	13·51	107·6	1351		
	3	76·955	·9645	10·03	9·674	1048·7	13·63	108·4	1362		
	4	77·145	·9634	10·03	9·662	1107·8	14·36	114·7	1441		
Jowitt	1	73·928	·9186	10·04	9·222	972·0	13·15	105·4	1324	1522	
	2	74·120	·9249	10·03	9·276	1303·7	17·59	140·5	1766		
	3	72·058	·8995	10·03	9·022	1010·8	14·03	112·0	1407		
	4	73·840	·9214	10·03	9·241	1170·9	15·86	126·7	1592		
Vickers	1	68·631	·8811	10·04	8·846	792·1	11·54	89·54	1125	1158	One specimen failed to stand tempering, one slightly split.
	2	70·043	·9010	10·03	9·037	934·9	13·35	103·5	1300		
	3	66·651	·8589	10·02	8·606	718·7	10·78	83·52	1049		
Crewe "rivet steel".	1	75·751	·9731	9·98	9·711	149·6	1·97	15·40	193·5	180·6	
	2	75·820	·9790	9·97	9·760	162·3	2·14	16·63	208·9		
	3	75·553	·9736	9·97	9·706	149·6	1·98	15·41	193·6		
	4	77·210	·9909	10·00	9·909	99·88	1·29	10·08	126·6		
Crewe "spring steel"	1	75·012	·9763	10·02	9·783	1093·3	14·58	111·7	1404	1364	Two specimens failed to stand tempering; other two badly split.
	2	76·086	·9837	10·02	9·857	1039·0	13·65	105·4	1324		
Clemandot........ ..	A1	79·518	—	9·90	9·914	872·9	10·98	88·07	1106	1116	These bars are of compressed steel, tempered and magnetised by the maker; they are rather roughly finished, and their dimensions could only be approximately determined Tested as received from Paris.
	2	80·335	—	9·95	10·04	968·6	12·06	96·48	1212		
	3	80·208	—	9·98	10·03	956·9	11·93	95·41	1199		
	4	79·94	—	9·96	9·993	1127·1	14·10	112·8	1417		
	5	80·542	—	9·97	10·07	1010·8	12·55	100·4	1261		
	6	79·958	—	9·96	9·995	1284·1	16·06	128·5	1614		
	B7	80·322	—	9·88	10·04	741·2	9·227	73·83	928	928	Compressed, but untempered.
Marchal	1	78·478	·9917	10·00	9·917	1750·7	22·31	176·5	2218	1839	Tempered and magnetised by the maker. Tested as received from Paris.
	2	80·253	1·011	10·00	10·106	1556	19·39	154·0	1934		
	3	79·380	1·014	10·00	10·136	1372	17·28	135·4	1701		
	4	79·540	1·001	10·00	10·01	1645	20·68	164·3	2065		
	5	78·260	·9992	10·00	9·992	1200·5	15·34	120·1	1510		
	6	79·488	1·0006	10·00	10·006	1279·8	16·10	127·9	1607		
"Allevard"	1	79·900	·9996	9·86	8·656	878·9	11·00	89·17	1120	1318	Tempered in mercury.
	2	80·415	1·0064	9·87	9·934	1199·4	14·92	120·7	1517		
	3	79·600	·9944	9·89	9·835	1480·5	18·60	150·5	1892	1664	Tempered in water.
	4	79·765	1·0054	9·90	9·954	1138·6	14·27	114·4	1437		

however, considerably *increased* by the same treatment, as will be seen from the tabulated result of the *experiments*.

The magnetometer employed is simply a Thomson mirror, suitably mounted with levelling screws, and placed over the centre of a millimetre scale two metres long. The scale for reading the deflections is of the usual straight kind, with central zero, and is

Fig. 1.—Electromagnet.

placed at a constant distance of 100 cm. from the mirror. The magnets were in most cases tested with their centres at distances of 100 and 75 cms. from the mirror, the mean of readings on either side of zero in each position was taken. The moments have been calculated from the formula: $M = \frac{H}{2}\frac{(r^2 - l^2)^2}{r}\tan\theta$; r being the distance of the magnet from the mirror, and l half the length of magnet (=5 cms. very nearly).

Fig. 2.—Magnetometer.

The maximum value of 2θ being only about 4deg., $\tan\theta$ has been taken as equal to $\frac{\tan 2\theta}{2}$.

The value of H for the room in the General Post Office in which the first series of experiments were made was determined both by the coil method and by the method of vibrations.

1. Experiments with a coil of 18 turns, and a mean radius of (15·6) cms.:

Date.	Current.	Distance of coil from mirror.	Deflection.	Tan. θ	H.	Mean value of H.
	Amperes.	Mm.	Mm.			
June 12th ...	·5	1,000	21·01	·01047	·1268	
" " ...	[illegible]	600	96·14	·04808	·1275	
" 15th ...	·5	1,000	20·93	·01046	·1269	·1276
" " ...	·47	750	44·79	·0224	·1285	
" " ...	·44	600	79·53	[illegible]	·1282	

2. Experiments with glass hard magnetised wires.—H calculated from the formula, $H^2 = \frac{8\pi r K}{T^2 (r^2 - l^2)^2 \tan\theta}$.

June 15.	Moment of inertia, K.	r.	Deflect.	Tan. θ.	Time of complete vibration, T.	H.	Mean.
		Mm.	Mm.		Secs.		
No. 1 wire	5·6421	400	17·58	·00879	7·075	·1278	
2 "	5·574	"	12·14	006069	8·462	·1278	1·277
"	5·574	"	17·48	008738	7·082	·1276	

The values of H thus obtained, although agreeing closely with each other, being surprisingly low, the same wire magnets were taken to a spot 4 or 5 miles from the G.P.O., and it was then found that their periods of vibration were reduced respectively to 5·99, 7·14, and 5·95 seconds, making H about ·1782, and showing that the previous determinations were fairly accurate.

During the second series of experiments the following values of H were obtained by the coil method:

Date.	Current ampere.	Distance of coil from mirror.	Mean deflection.	Tan. θ	H.	Mean value of H.
		Mm.	Mm.			
Aug. 23.........	·48	1,000	20·09	·010045	·1269	
" 23.........	·47	750	44·37	·022185	·1297	·1280
" 24.........	·455	"	42·70	·021350	·1269	
" 24.........	·44	"	41·86	·02093	·1287	

Taking the strongest magnets of each group in the second series of experiment, and arranging them in order, we have

	Induction.
Marchal, No. 1	2,835
Clemandot, No. 1	2,362
"Allevard," No. 3 (water tempered)	1,879
Ashforth, No. 4	1,779
Jowitt, No. 2	1,745
Wall, No. 4	1,689
Saunderson, No. 1	1,610
"Allevard," No. 2 (mercury tempered)	1,528
Crewe "spring," No. 1	1,436
Vickers, No. 2	1,297
Crewe "rivet," No. 3	217

If we take the mean induction of the magnets of each group, which is probably a fairer method of comparison, we obtain a slightly different order—viz.:

	Mean induction.
Marchal	2,540
Clemandot	2,265
Ashforth	1,704
Allevard (water tempered)	1,660
Wall	1,519
Jowitt	1,503
Saunderson	1,435
Crewe "spring"	1,391
Allevard (mercury tempered)	1,315
Vickers	1,174
Crewe "rivet"	[illegible]

The marked superiority of the Marchal magnets over those made of English steel is evidently not due to the method of magnetisation adopted by the maker, since their mean induction was increased by 38 per cent., and their magnetisation rendered more uniform by re-magnetisation in our coil. Their greater strength must therefore be due either to the quality of the steel, or to the mode of tempering—most probably the latter. The Clemandot compressed steel magnets, too, which were very poor when first tested, had their mean induction more than doubled by re-magnetisation.

In view of the results of these experiments, I purpose to investigate further the methods of tempering magnet steel. It is pretty clear there is room for improvement in our present practice.

I am indebted to M. Trotin, of the French Telegraphic Administration, for having kindly procured the French specimens for me.

The induction in these short straight bars is comparatively low, because we measure only the lines (Maxwell's B) that radiate from the ends. Prof. Perry has succeeded in getting as much as 12,700, with Jowitt steel, through the middle of a magnet of a special horseshoe form. It ought, apparently, to be possible to get about 20,000 with the best French steel.

I happen to have in my possession two small horseshoe magnets of Allevard steel which were made for Mr. H. Edmunds, and magnetised in Paris in 1881. The induction of one is now 3,287·3, and of the other 3,552·5. They have never been touched since 1881. The retentiveness is therefore very good.

All these measurements have been made with great patience and skill by Mr. Henry Hartnell.

THE EFFECT OF OXIDATION ON THE MAGNETIC PROPERTIES OF MANGANESE.*

BY L. T. O'SHEA, B.SC.

When manganese steel drillings are oxidised they become magnetic, the development of magnetic properties being due to removal of manganese by oxidation, etc., and to the magnetic properties of the oxide of iron (probably magnetic oxide) formed. When the oxidised product is reduced in hydrogen, the iron oxide is converted into metallic iron and the manganese remains as manganous oxide (MnO). The reduced steel is now powerfully magnetic in virtue of the magnetic properties of unalloyed metallic iron. During the process of oxidation, the proportion of manganese to iron oxidised in a given time is only very slightly in excess of the proportion of manganese to iron in the original steel. The excess of manganese oxidised is in all probability due partly to the greater susceptibility of manganese to oxidation, and partly to the heterogeneous structure of the steel.

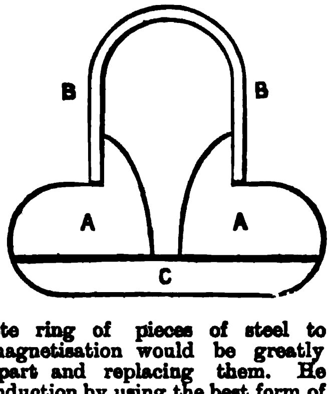
The following discussion took place on the papers of Messrs. Swinburne and Bourne (*Electrical Engineer* for September 12th, p. 220), Preece and O'Shea:

Mr. Preece said it was his intention to pursue the question of tempering, and he would be thankful for any suggestions. He was going to take a great number of samples of steel, raise them to different temperatures, and quench them in different cooling mixtures, such as oil, mercury, and water.

Prof. Barrett remarked that he believed the exact temperature at which the heated steel was hardened by quenching as well as the ratio of quenching would be found to be important. If quenched short of the recalescent point no hardening ensued—steel could not be tempered, hence the subject connected itself with the committee, of which he was secretary, on magnetic and other phenomena connected with the recalescent point in steel. Dr. Ball, in a recent paper read before the Iron and Steel Institute, said that both the tensile strength and magnetic properties of steel underwent a marked change when the steel was quenched at two critical points—one 800deg. C., and the other about 1,300deg. C. He hoped Mr. Preece would send specimens of his steel to the Recalescent Committee. In regard to Mr. O'Shea's paper, Prof. Barrett remarked it was Mr. Hadfield who first noticed that magnetic steel filings became magnetic in heating to whiteness. He had, through Mr. Hadfield's kindness, been able to make many experiments on this question, the results of which he had communicated to the Royal Dublin Society. Mr. O'Shea had shown that oxidation could hardly be regarded as sufficient cause, and he (Prof. Barrett) was inclined to think the cause was due to some dissociation or decomposition of the magnetic steel, whereby free iron particles were liberated. This effect did not occur in wire nor filings wrapped in platinum foil, but this might be explained by the more rapid cooling which took place in the filings, whereby the molecular steel at a high temperature might be fixed.

Mr. O'Shea, in reference to Prof. Barrett's remarks on dissociation, pointed out that steel in the mass did not present those magnetic properties to the same extent as it did in the filings, and why should dissociation take place in the filings when it did not in the mass? His point was that oxidation did take place, but in the case of a mass of steel that oxide scaled off and left the metal perfectly free from oxide; whereas in the case of filings the oxide remained with them and they remained magnetic; then it was that dissociation took place. When the two were oxidised they first had the oxide of iron exerting its magnetic effect, and then after reduction the metallic iron exerted its magnetic effect.

Prof. Perry said that there could be no more useful work than that which was being undertaken by Mr. Preece and his assistants, and as Mr. Preece subjected all the specimens to the same treatment his test was a fair one. But was this the same in the matter of *tempering?* He gathered that only one English specimen was tempered in mercury, and the Allevard specimens had not been tempered by Mr. Preece. He put it that this was really the important matter, the tempering, and he was glad to think that Mr. Preece intended to go thoroughly into the effect of tempering. Until that was done these results were useless. He (Mr. Perry) had tempered differently three similar specimens of the same steel, one in water, one in a little mercury, one in a large bath of mercury. The third had an enormously greater retentiveness (he was not sure, but thought it was three times) than the first. He had the notion that steel must remain in a magnetic circuit of small magnetic resistance if it was to retain its induced magnetisation; that was, suppose a nearly complete ring of pieces of steel to have been magnetised, the magnetisation would be greatly diminished by taking them apart and replacing them. He obtained very great permanent induction by using the best form of magnet he could think of for that purpose, although it might be useless for all other purposes. B was a very broad, very thin strip of glass-hard steel fitted to soft iron pole-pieces, A A, C being a



well-fitted keeper. The force required to pull off the keeper enabled the total induction to be calculated. As the dimensions were great at right angles to the paper, it was obvious that whether the keeper was on or off there was always extremely little total magnetic resistance.

Sir Wm. Thomson said that Sir A. Gray and himself had made a large number of experiments in the physical laboratory of the Glasgow University, comparing steel from different makers. It was very difficult to get from the same maker constant results. Over and over again the specimens were found to differ exceedingly in magnetic quality from one another by 10 or 20 per cent., though alleged by the maker to be as nearly the same as he could make them. On the other hand, they would get a very good specimen, and would ask for one like that, but had very great difficulty in getting what they desired. The specimens could not be too hard, and even when he asked for them to be glass hard those sent did not come up to what he knew they ought to have. He returned them to be made as hard as they could be made, and only then did he get good results. He was exceedingly glad Mr. Preece had taken the subject up, and he thought the results would be exceedingly valuable and interesting, not to science only, but to applied science. There was a great career for steel magnets.

Sir A. Gray remarked that the induction obtained by Sir William Thomson and himself was about 12,000.

Sir William Thomson said that they reckoned the standard result for the very best steel used to be 100 C.G.S. intensity of magnetisation per gramme weight; that corresponded to only about 10,000 induction, and he was pleased to see the results put forward by Mr. Preece were enormously better than what was supposed to be obtainable. C.G.S. per gramme was a very convenient way of putting it. In connection with his experiments, he multiplied by the specific gravity of steel 7·8, so that 100 magnetic moment per gramme gave 780 magnetic moment per cubic centimetre intensity of magnetisation, and that was the best way of putting it. This was the highest intensity of magnetisation that could be obtained.

* Abstract of paper read before the British Association.

ELECTRO OPTICS.*

Some progress in the experiments for the conduction of which the committee were appointed has been made by Dr. Kerr, but the committee regret to have to report that they are still only in the preliminary stage. The first trials were made last winter at some length, but were without effect. The difficulty arose from some unexpected and serious defects in the new plate cell, which are now being remedied.

The committee hope that the apparatus may be in working order shortly, and look forward to being able to make a full report next year. They ask for reappointment.

POLARISATION OF THE EARTH.

Mr. Charles Cuttriss, in the New York *Electrical Engineer*, gives an account of some tests made on certain phenomena on the ocean underground cable, showing the effect of heavy currents in polarising the ground when used as a return circuit for an electric road, and the great distance at which it could be felt. The ocean companies' underground lines extend from New York north to Bronx river, 12 miles; and south to Coney Island, 12 miles; and the grounding of the lines at these stations gives a ready way of detecting in New York any differences of potential at either end. At noon on August 17th there was a fairly steady (and normal, apparently) difference of potential between Bronx river and New York of ·8 to 1 volt; between New York and Coney Island a difference of potential varying rapidly from ·1 to 3·5 volts, the extremes often occurring in five seconds. The experiments were now abandoned till midnight, when the electric cars shut down for the night. At 12.25 a.m. a heavy current was found between Coney Island and New York, but no running of cars could be detected. Measurements showed a difference of potential of 4·5 volts. This remained fairly steady till 1 a.m., when it commenced to fall gradually. At 1.15 the mirror showed equipotential at either end, but the mirror still continued to move, crossing zero, and showing a negative wave till it reached 3·5 volts. It then began to drop again, reaching equipotential at 1.40 a.m., and then continued till it showed ·8 volt, where it remained steady, showing the earth at Coney Island had become normal. The potential was checked every five minutes by Bronx river circuit to make sure the variations were not due to local causes. It is thus evident that there is actual polarisation of the ground for an unknown distance from the rails of the electric road. If the normal condition of the ground can thus be raised 4·5 volts by a disturbing force at distance of half a mile, the close proximity of the two systems, says Mr. Cuttriss, would certainly render the practical working of the weaker one—the cable—almost an impossibility. The great difference in this problem, over that of equalising telephone or telegraph circuits, is in the extreme delicacy of the receiving apparatus and the enormous electrostatic capacity of long lengths of submarine cable.

* Report of the committee, consisting of Dr. John Kerr (chairman), Sir William Thomson, Prof. Rücker, and Mr. R. T. Glazebrook (secretary), appointed to co-operate with Dr. Kerr in his researches on electro optics, read at the British Association meeting.

THE

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GAS COMPANIES AND ELECTRIC LIGHTING.

Punch is supposed by the average Englishman to reach the acme of light and fantastic literature, but his reign will be disputed now and again by the *Gas Journal*. The writer of "Electric Lighting Memoranda" therein is worthy of a high niche in the temple of jokists. Talk about the dull, unenlightened, conservative Britisher, this individual takes the cake. He understands not the simplest rudiments of business, yet talks as if possessed of the experience and acumen of all the ages. He writes on electrical matters, while every sentence shows his intense ignorance of the subject. He speaks of schemes as commonly sanctioned and approved by the electrical industry which have never been so sanctioned or approved, and which have commended themselves solely to the inventors thereof. This wise and sapient critic sets up weekly men of straw, and proceeds to pummel and buffet them to his heart's content. How gratified he must be with his lucubrations, though his readers may, if they believe all he tells them, find they are blind led by the blind and fallen into the ditch. As well attempt to knock down the fortress of Gibraltar with cannon balls made of dough, as effect any harm to electric lighting with the quips and arguments put forth by our contemporary. All local bodies that interest themselves in the progress of electricity are belaboured with epithets to frighten them back into the straight road that useth gas and nought else. Every individual in a local body who takes such an interest is dubbed a faddist, or has it insinuated he is a fool, a kind of criticism at once bombastic and easily produced. What is the last amusing feature? We are told that "One seldom hears anything now of that remarkable fad of the scientific electrician, who is always supposed to be so much more advanced and intelligent a person than the gas engineer, the tower system of street lighting." It would be instructive to most English electricians to know who the "scientific electricians" in this country are who supported the "tower system." The "scientific electrician" knows too much about the law of inverse squares, and the practical electrician knows too much about the exigencies of street lighting to fall into errors of this description. Again, we are told that the "discovery of French measurement for arc lamps" was contemporaneous with the discovery of the "tower system," with the senile remark that we have the former "still with us, although it is only tacitly used by the Brush Company." What is a "tacit use," oh, worthy writer? A tacit understanding may pass muster, but a "tacit use" never. But who discovered this wonderful "French measurement," and why divide by four?

Among this week's memoranda, however, is a paragraph commenting on a letter of Mr. William Livesey's, which treats of the position gas com-

need only a modicum of knowledge and a keen sense of *esprit de corps* in the engine-room, which could hardly exist if a savage assault occurred. There would have been differences before the final rupture. We trust, for Mr. Massingham's own sake, none of our contemporaries will feel disposed to insert his letter *in extenso*. It is unworthy of him, and no answer to the statements made. We are perfectly certain that none of the technical journals recognised, in one of their correspondents, an old employé of his, otherwise less prominence would have been given to the diatribes.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

LECTURE I.—HISTORICAL SKETCH.

(*Continued from page 223.*)

The effect which an electric current, flowing in a wire, can exercise upon a neighbouring compass needle, was discovered by Oersted in 1820. This first announcement of the possession of magnetic properties by an electric current was followed speedily by the researches of Ampère, Arago, Davy, and by the devices

FIGS. 1 and 2.—Sturgeon's First Electromagnet.

of several other experimenters, including De la Rive's floating battery and coil, Schweigger's multiplier, Cumming's galvanometer, Faraday's apparatus for rotation of a permanent magnet, Marsh's vibrating pendulum, and Barlow's rotating star-wheel. But it was not until 1825 that the electromagnet was invented. Davy had, indeed, in 1821 surrounded with temporary coils of wire the steel needles upon which he was experimenting, and had shown that the flow of electricity around the coil could confer magnetic power upon the steel needles. But from this experiment it was a grand step forward to the discovery that a core of soft iron, surrounded by its own appropriate coil of copper, could be made to act not only as a powerful magnet, but as a magnet whose power could be turned on or off at will, could be augmented to any desired degree, and could be set into action and controlled from a practically unlimited distance.

The electromagnet, in the form which can first claim recognition for these qualities, was devised by William Sturgeon, and is described by him in the paper which he contributed to the *Proceedings* of the Society of Arts in 1825, accompanying a set of improved apparatus for electromagnetic experiments. The Society of Arts rewarded Sturgeon's labours by awarding him the silver medal of the society and a premium of 30 guineas. Amongst this set of apparatus are two electromagnets, one of horseshoe shape (Figs. 1 and 2) and one a straight bar (Fig. 3). It will be seen that the former figures represent an electromagnet consisting of a bent iron rod about 1ft. long and ½in. in diameter, varnished over and then coiled with a single left-handed spiral of stout uncovered copper wire of 18 turns. This coil was found appropriate to the particular battery which Sturgeon preferred, namely, a single cell containing a spirally enrolled pair of zinc and copper plates of large area (about 130 square inches) immersed in acid; which cell, having small internal resistance, would yield a large quantity of current when connected to a circuit of small resistance. The ends of the copper wire were brought out sideways and bent down so as to dip into two deep connecting cups, marked Z and C, fixed upon a wooden stand. These cups, which were of wood, served as supports to hold up the electromagnet, and having mercury in them served also to make good electrical connection. In Fig 2 the magnet is seen sideways, supporting a bar of iron, *y*. The circuit was completed to the battery through a connecting wire, *d*, which could be lifted out of the cup Z, so breaking circuit when desired, and allowing the weight to drop. Sturgeon added in his explanatory remarks that the poles, N and S, of the magnet will be reversed if you wrap the copper wire about the rod as a right-handed screw instead of a left-handed one, or, more simply, by reversing the connections with the battery, by causing the wire that dips into the Z cup to dip into the C cup, and *vice versa*. This electromagnet was capable of supporting 9lb. when thus excited.

Fig. 3 shows another arrangement to fit on the same stand. "This arrangement communicates magnetism to hardened steel bars as soon as they are put in, and renders soft iron within it magnetic during the time of action; it only differs from Figs. 1 and 2 in being straight, and thereby allows the steel or iron bars to slide in and out.

For this piece of apparatus and other adjuncts accompanying it, all of which are described in the society's *Transactions* for 1825, Sturgeon, as already stated, was awarded the society's silver medal and a premium of 30 guineas. The apparatus was deposited in the museum of the society, which therefore might be supposed to be the proud possessor of the first electromagnet ever constructed. Alas, for the vanity of human affairs, the society's museum of apparatus has long been dispersed, this priceless relic having been either made over to the now defunct Patent Office Museum, or otherwise lost sight of.

Sturgeon's first electromagnet, the core of which, weighing about 7oz., was able to sustain a load of 9lb., or about 20 times

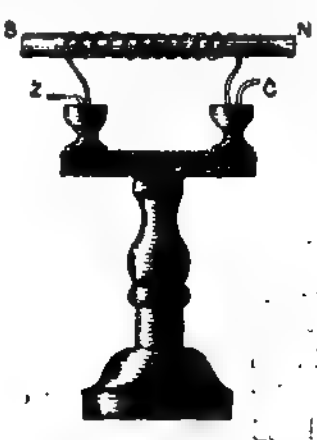


FIG. 3.—Sturgeon's Straight Bar Electromagnet.

its own weight. At the time it was considered a truly remarkable performance. Its single layer of stout copper wire was well adapted to the battery employed, a single cell of Sturgeon's own particular construction, having a surface of 130 square inches, and therefore of small internal resistance. Subsequently, in the hands of Joule, the same electromagnet sustained a load of 50lb., or about 114 times its own weight. Writing in 1832 about his apparatus of 1825, Sturgeon used the following magniloquent language:

"When first I showed that the magnetic energies of a galvanic conducting wire are more conspicuously exhibited by exercising them on soft iron than on hard steel, my experiments were limited to small masses—generally to a few inches of rod iron about half an inch in diameter. Some of those pieces were employed while straight, and others were bent into the form of a horseshoe magnet, each piece being encompassed by a spiral conductor of copper wire. The magnetic energies developed by these simple arrangements are of a very distinguished and exalted character, as is conspicuously manifested by the suspension of a considerable weight at the poles during the period of excitation by the electric influence.

"An unparalleled transiliency of magnetic action is also displayed in soft iron by an instantaneous transition from a state of total inactivity to that of vigorous polarity, and also by a simultaneous reciprocity of polarity in the extremities of the bar, versatilities in this branch of physics for the display of which soft iron is pre-eminently qualified, and which by the agency of electricity become demonstrable with the celerity of thought, and illustrated by experiments the most splendid in magnetics. It is, moreover, abundantly manifested by ample experiments that galvanic electricity exercises a superlative degree of excitation on the latent magnetism of soft iron, and calls for its recondite powers with astonishing promptitude to an

* Cantor Lecture, delivered before the Society of Arts.

intensity of action far surpassing anything which can be accomplished by any known application of the most vigorous permanent magnet, or by any other mode of experimenting hitherto discovered. It has been observed, however, by experimenting on different pieces selected from various sources, that, notwithstanding the greatest care be observed in preparing them of a uniform figure and dimensions, there appears a considerable difference in the susceptibility which they individually possess of developing the magnet powers, much of which depends upon the manner of treatment at the forge, as well as upon the natural character of the iron itself.

"The superlative intensity of electromagnets, and the facility and promptitude with which their energies can be brought into play, are qualifications admirably adapted for their introduction into a variety of arrangements in which powerful magnets so essentially operate, and perform a distinguished part in the production of electromagnetic rotations, whilst the versatilities of polarity of which they are susceptible are eminently calculated to give a pleasing diversity in the exhibition of that highly-interesting class of phenomena, and lead to the production of others inimitable by any other means."

Sturgeon's further work during the next three years is best described in his own words:

"It does not appear that any very extensive experiments were attempted to improve the lifting power of electromagnets from the time that my experiments were published in the *Transactions* of the Society of Arts, etc., for 1825, till the latter part of 1828. Mr. Watkins, philosophical instrument maker, Charing Cross, had, however, made them of much larger size than any which I had employed, but I am not aware to what extent he pursued the experiment.

"In the year 1828, Professor Moll, of Utrecht, being on a visit to London, purchased of Mr. Watkins an electromagnet weighing about 5lb.—at that time I believe the largest which had been made. It was of round iron, about 1in. in diameter, and furnished with a single copper wire twisted round it 83 times. When this magnet was excited by a large galvanic surface, it supported about 75lb. Professor Moll afterwards prepared another electromagnet, which, when bent, was 12½in. high, 2¼in. in diameter, and weighed about 26lb.; prepared like the former with a single spiral conducting wire. With an acting galvanic surface of 11 square feet, this magnet would support 154lb., but would not lift an anvil which weighed 200lb.

"The largest electromagnet which I have yet [1832] exhibited in my lectures weighs about 16lb. It is formed of a small bar of soft iron, 1½in. across each side. The cross-piece which joins the poles is from the same rod of iron, and about 3¾in. long. Twenty separate strands of copper wire, each strand about 50ft. in length, are coiled round the iron one above another from pole to pole, and separated from each other by intervening cases of silk. The first coil is only the thickness of one ply of silk from the iron; the twentieth, or outermost, about ½in. from it. By this means the wires are completely insulated from each other without the trouble of covering them with thread or varnish.

The ends of wire project about 2ft. for the convenience of connection. With one of my small cylindrical batteries, exposing about 150 square inches of total surface, this electromagnet supports 400lb. I have tried it with a larger battery, but its energies do not seem to be so materially exalted as might have been expected by increasing the extent of galvanic surface. Much depends upon a proper acid solution; good nitric or nitrous acid, with about six or eight times its quantity of water, answers very well. With a new battery of the above dimensions and a strong solution of salt and water, at a temperature of 190deg. F., the electromagnet supported between 70lb. and 80lb., when the first 17 coils only were in the circuit. With the three exterior coils alone in the circuit, it would just support the lifter, or cross-piece. When the temperature of the solution was between 40deg. and 50deg., the magnetic force excited was comparatively very feeble. With the innermost coil alone and a strong acid solution this electromagnet supports about 100lb.; with the four outermost wires about 250lb. It improves in power with every additional coil until about the twelfth, but not perceptibly any further; therefore the remaining eight coils appear to be useless, although the last three, independently of the innermost 17, and at the distance of half an inch from the iron, produce in it a lifting power of 75lb.

"Mr. Marsh has fitted up a bar of iron much larger than mine, with a similar distribution of the conducting wires to that devised and so successfully employed by Prof. Henry. Mr. Marsh's electromagnet will support about 560lb. when excited by a galvanic battery similar to mine. These two, I believe, are the most powerful electromagnets yet produced in this country.

"A small electromagnet which I also employ on the lecture-table, and the manner of its suspension, is represented by Fig. 4. The magnet is of cylindric rod iron, and weighs 4oz.; its poles are about a quarter of an inch asunder. It is furnished with six coils of wire in the same manner as the large electromagnet before described, and will support upwards of 50lb.

"I find a triangular gin very convenient for the suspension of the magnet in these experiments. A stage of thin board, supporting two wooden dishes, fastened, at a proper height, to two of the legs of the gin. Mercury is placed in these vessels, and the dependent amalgamated extremities of the conducting wires dip into it—one into each portion.

FIG. 4.—Sturgeon's Lecture-table Electromagnet.

"The vessels are sufficiently wide to admit of considerable motion of the wires in the mercury without interrupting the contact, which is sometimes occasioned by the swinging of the magnet and attached weight. The circuit is completed by other wires, which connect the battery with these two portions of mercury. When the weight is sppported as in the figure, if an interruption be made by removing either of the connecting wires, the weight instantaneously drops on the table. The large magnet I suspend in the same way on a larger gin. The weights which it supports are placed one after another on a square board, suspended by means of a cord at each corner from a hook in the cross-piece, which joins the poles of the magnet.

"With a new battery and a solution of salt and water at a temperature of 190deg. F., the small electromagnet, Fig. 3, supports 16lb."

(To be continued.)

NOTES FOR A DISCUSSION ON RECENT DETERMINATIONS OF THE RESISTANCE OF MERCURY.*

BY R. T. GLAZEBROOK.

We are here to-day to discuss some of the recent determinations of the value of the ohm when expressed as the resistance of a column of mercury, with a view to seeing if any action is practicable by which the standards in general use may be brought nearer to their theoretical value than they are at present.

The time is opportune, for we have the advantage of having in Leeds Prof. Mascart, of Paris, and Prof. Rowland, of Baltimore, under whose directions some of the most important of the investigations we are to consider to-day have been made, and Prof. Barker, one of the American representatives at the Paris Congress. Moreover, it seems probable that a Congress will again meet shortly to consider this queston, and a preliminary discussion here may be of value in clearing the ground.

The question at issue is whether the results of experiment are sufficiently in accord with each other to render it probable that any number adopted by us would be generally accepted, and, if so, to determine what that number is.

The problem has two sides. The resistance of a wire is expressed by means of one series of experiments in terms of a length and a time, while by another series of experiments it is expressed in terms of the resistance of mercury, and thus the resistance of mercury is found absolutely. Frequently, however, there is an intermediate step; the resistance of the wire is expressed in terms of some standard resistance, and this standard is expressed in terms of mercury.

In the table, the first eight lines give the results of observers who have made absolute determinations, and have also compared the coils used by them directly with the resistance of mercury. In the next four lines are the results of comparisons between the B.A.U. and mercury, while in the remainder of the table are given the results of measurements, in which the

* Paper read before the British Association.

VALUE OF OHM EXPRESSED AS THE RESISTANCE OF A COLUMN OF MERCURY.

	Observer.	Date.	Method.	Value of B.A.U. in ohms.	Value of 100 centimetres of mercury in B.A.U.	Value of ohm in centimetres of mercury.
1	Lord Rayleigh	1882	Rotating coil	·98651	·95412	106·24
2	Lord Rayleigh	1883	Lorenz method	·98677	—	106·21
3	G. Wiedemann...	1884	Rotation through 180deg.......	—	—	106·19
4	Mascart	1884	Induced current	·98611	·95374	106·33
5	Rowland	1887	Mean of several methods	·98644	·95349	106·32
6	Kohlrausch	1887	Damping of magnets	·98660	·95338	106·32
7	Glazebrook	1882 and 88.	Induced currents..	·98665	·95352	106·29
8	Wuilleumeier	1890	....	·98686	·95355	106·27
		Mean		·98656	—	—
9	Strecker........	1885	An absolute determination of resistance was not made. The value ·98656 has been used.....	....	·95334	106·32
10	Hutchinson	1888			·95352	106·30
11	Salvioni	1890			·95332 or	106·33
12	....				·95404	
		Mean without 12			·95355	106·28

	Observer.	Date.	Method.	Value of B.A.U. in ohms.	Value of 100 centimetres of mercury in B.A.U.	Value of ohm in centimetres of mercury.
13	H. F. Weber	1884	Induced current	Absolute measurements compared with German silverwire coils issued by Siemens or Strecker.		105·37
14	H. F. Weber	—	Rotating coil..................			106·16
15	Roiti	1884	Mean effect of induced current			105·89
16	Himstedt	1885	....			105·98
17	Dorn	1889	Damping of a magnet			106·24
18	Wild	1883	,, ,, ...			106·03
19	Lorenz	1885	Lorenz method			105·93

absolute resistance of a wire was compared with that of a coil issued by Siemens or Strecker.

The methods employed to compare a standard resistance with that of mercury are all very similar in their nature, and the experiment is not one of very great difficulty. Accordingly we find that the results of the experiments are fairly concordant.

Column five gives the values found in B.A. units for the resistance of a column of mercury 1 metre long, 1 square mm. in section at 0deg. C.—a Siemens unit, as it is called. The values found by Lord Rayleigh and M. Mascart are higher than later ones. A comparison of the values found for the B.A.U. in ohms and for the Siemens unit in B.A.U. by M. Mascart, leads to the conclusion that possibly his B.A.U. had changed a little between the time at which it was compared with the standards at Cambridge and the time at which it was used. As to Lord Rayleigh's value, the fact that the coil F was his principal standard, and that coil F has certainly changed relatively to the other coils in the last two years, may help to explain the difficulty, but it must be remembered that F had the same value relatively to the others in 1888 as it had in 1881, when examined by Dr. Fleming.

The other numbers are in close accord, except one result of Salvioni's, which must, I think, be capable of a simple explanation.

Strecker, Kohlrausch, and Salvioni differ somewhat from Wilkes and myself; in consequence, I believe, of the fact that they worked at the temperature of the room, while Wilkes and I worked at the temperature of melting ice. A small change in the temperature coefficient used by them would easily account for the difference.

Wuilleumeier's mercury coils were the same as those employed by Mascart, Benoit, and de Nerville. We may thus take ·9535 B.A.U. as being very accurately the resistance of a column of mercury 100 cm. long 1 square mm. in section.

But when we enquire what are the results which have been obtained for the value, in ohms, of the B.A.U., or of the mercury unit, the discrepancies are considerable.

Let us consider the methods. An admirable summary of these will be found in Wiedemann's *Electricitat*, vol. iv., p. 910, or in Mascart and Joubert's *Leçons sur l'Electricité*, ii., pp. 581, *et seq.* They have also been critically discussed by Wiedemann and by Lord Rayleigh in the *Phil. Mag.*, vol. xiv., 1882.

We will take them in order.

I.—*Kirchhoff's Method.*

This has been used by Weber, Rowland, Mascart, and Glazebrook.

The formula involved may be written—

$$R = \frac{4\pi M}{T} \cdot h \cdot \frac{a}{\beta}.$$

Where M is the coefficient of induction between the coils, T the time of swing of the galvanometer needle, a the deflection due to the primary current, β the throw due to the induced current, and h a ratio either of two galvanometer constants or of two resistances—in the expression all small corrections are omitted.

The main difficulty is in calculating the value of M, which depends approximately on $\frac{a^2}{b}$, if a is the radius of either coil and b the distance between the coils.

In the coils used by myself the value of a was about 26 cm.; that of b varied from 12 to 24 cm. An error of ·1 mm. in b produces an error in the result of 1 in 1,500 to 1 in 2,000. In one position of the coils, the correction arising from the fact that the cross-section of the channel was of finite area was less than 1 in 1,000. There should, it seems to me, be no difficulty in finding M to one or two in 10,000. The coils used by Rowland and Weber in their earlier experiments, and by Mascart, were smaller. In his last experiment in 1883 Weber used coils of 32 cm. radius. In their later experiments Rowland and Kimball had large coils, about 50 cm. in radius.

The various results are:

Rowland	106·29
Mascart	106·33
Glazebrook	106·29
H. F. Weber	105·37

It will be noticed that all H. F. Weber's results are very low. He used as his standard wire a 10-Siemens unit taken from a resistance-box, not a coil which had been compared directly with mercury, and it seems possible that a common error in this affects all his results, he also used large magnets. The other values are in fair agreement, though we may probably agree with Lord Rayleigh in thinking that the limit of accuracy of the method has not been reached.

II.—*Weber's Method* (1).

The approximate formula again is

$$R = \frac{2\pi G g}{T\beta} = \frac{4\pi^2 N N^1}{T\beta} \cdot \frac{a^2}{A}.$$

Where G is the constant of the galvanometer, g the area of the inductor, and in the second expression a is the radius of the inductor, A, of the galvanometer, N and N^1 being the number of turns on the two respectively.

This method was followed by Mascart, who used with a coil of 15 cm. diameter and a galvanometer the constant G, for which was compared with one of known constant—viz., the inductor. The time taken to turn the inductor was one-fifth of the time of vibration of the galvanometer needle.

There is the difficulty of making the axis vertical and the effect of the time of duration of current to consider.

My experiments show that if the circuit be open for one second, the time of swing being 23 seconds, then the deflections are reduced by ·1 per cent. With the circuit open for two seconds the effects are marked.

The same method has been used by G. Wiedemann, who is inclined to think it the best. He employed coils of W. Weber and Zollner, one metre in diameter, which were wound and measured twice. He calculated G using as galvanometer coil a counter-part of the inductor; the effect of the current was determined by measuring effects of a series of impulses at proper moments.

The time of turning the inductor was two seconds, while the period of the needle was one minute. This would tend to

reduce β, this to increase R, and hence decrease length of column, which was found by comparison with a Siemens unit, the same was compared with mercury.

Mascart thinks difficulties inspire with doubt the results thus obtained.

Experiments near the magnetic equator would, Lord Rayleigh points out, decrease the effect of level error. Wiedemann thinks this method is to be recommended for final determinations. Rowland criticises the method. The results obtained are:

Mascart	106·37
Wiedemann	106·19

III.—*Method of British Association Committee.*

$$R = \pi^2 N^2 a \Omega \cot. \phi$$

The only measurement, apart from corrections, that of mean radius. The corrections, however, are important, for the self-induction of the rotating coil requires to be known, while the magnetic field in which the coil is moving is modified by the presence of the magnet at its centre, so that the magnetic moment of this magnet has to be determined. In order to reduce the amount of this correction, this moment is made small, and this again leads to difficulties. The following difficulties are urged by Wiedemann:

(1) Correction due to self-induction. (2) Difficulty of levelling. (3) Want of steadiness from draughts, etc. (4) Small magnetic moment.

In reply, we may say that

(1) Can be corrected for.

(2) Level error common to several methods.

(3) Effect can be eliminated by experiments with open circuit.

(4) Theory of the correction very simple; a knowledge of M/H only is required. The method was used by Lord Rayleigh, and by H. F. Weber, who used rotation about a horizontal diameter in the magnetic meridian to avoid the correction depending on $\frac{M}{H}$.

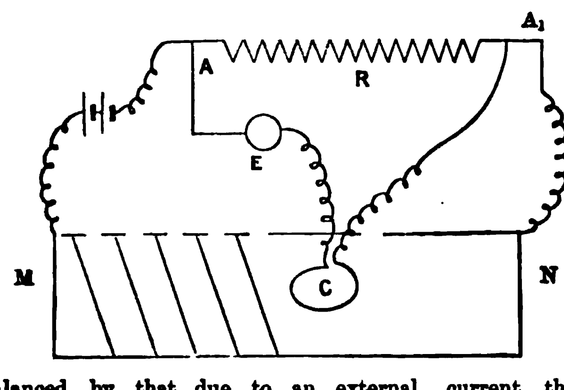
The results were:

Rayleigh	106·24
Weber	106·16

IV.—*Foster and Lippmann.*

$$R = 2\pi^2 \Omega \frac{a^2}{A} \cot \phi \, N N^1.$$

A rotating coil is employed, but contact is made only at the moment when the E.M.F. is a maximum, and E.M.F.



balanced by that due to an external current through a known resistance. Observations have been recently carried out by Wuilleumeier by this method with modifications. He used the induction from a long spiral, M N, 2 metres long 30 cm. diameter, placed east and west, wound with wire 2 mm. in diameter. A coil, C, wound on a disc of hard wood, 20 cm. in diameter, rotates in this, and the circuit is closed when the E.M.F. in this is a maximum; the E.M.F. thus produced is balanced against that produced by the current in the spiral when flowing through a resistance, R, the action of the earth's magnetism being compensated. One point, A, of this resistance is in contact with the coil through E, the other end is straight, and a movable contact is established at A_1, A_2, etc. Corrections for its ends were obtained by shifting the spiral coil. The resistance of R was about ·3 ohm, made of a strip German silver of rectangular section 34·72 metres long, 1 cm. broad, ·3 cm. thick, immersed in naphtha. The primary current was 12 amperes. A Lippmann electrometer was used. The E.M.F. was nearly four volts. The diameter of the rotating bobbin was 20 cm. Hence an error of ·1 mm. in mean radius makes error of 1 in 1,000. Formula assumes spiral uniformly wound. Result, 106·267.

V. (3). *Method of Damping.*

Set a magnet vibrating within a coil. The motion of the magnet sets up currents, which react on the magnet and damp it. A relation can be found between these currents, and the rate of damping. To a first approximation this gives

$$R = \frac{\pi}{2} \frac{1}{\tau} G^2 \frac{M}{H} \frac{(\pi^2 + \lambda^2)}{\lambda - \lambda_0}$$

G has to be compared with the constant of another coil, because of the size of the coil. Let h be the ratio

$$R = \frac{2\pi^3}{\tau} \frac{N^2 h^2}{A^2} \frac{\pi^2 + \lambda^2}{\lambda - \lambda_0} r^3 \tan \alpha.$$

Where A is the radius of the standard coil, N the number of its turns, α the deflection which the magnet produces in Gauss's first position, when at a distance, r.

Further corrections are required for length of magnet, and for the uncertainty as to the distribution of its magnetism and for self-induction.

In the opinion of Lord Rayleigh and Rowland, the final formula is enough to show that it cannot compete with the others.

Other difficulties are that calculation assumes the arc of oscillations is small, G is not independent of the displacement.

Currents are set up in the magnet, which affect its motion. A correction is required for temporary induced magnetisation by action of current, this may be appreciable. In general there are difficulties in applying the theory.

The method was used by H. F. Weber. His magnet was 8 cm. long, his coil 16 cm. in radius, and G was calculated, a uniform distribution of magnetism being assumed.

Dorn introduced corrections to the theory; he found G by comparison with a large coil, and compared result with a Siemens unit, verified by Strecker; his magnet was 17 cm. long, closely surrounded by a coil. Wild suspended the magnet bifilarly; it was 29 cm. long, the coil closely surrounded it; a resistance-box was used.

Kohlrausch's magnet was 20 cm. long, with brass ends; his galvanometer coil was close to it. G was compared with a large galvanometer. Resistance compared directly with a tube calibrated by Strecker.

The results are:

H. F. Weber	104·77
Dorn	106·24
Wild	106·03
Kohlrausch	106·32

VI.—*Lorenz Method.*

$$R = n M.$$

The main difficulty lies in the calculation of M. This is more easy than in I, for the disc can readily be measured.

In Lord Rayleigh's apparatus an error in the radius of coil does not greatly affect the result. Further increase of size possible and desirable. The smallness of effect, and therefore of R, is not fatal. See Lord Rayleigh's observations.

Thermo-electric effects can be compensated for.

Results:

Rayleigh	106·24
Rowland	106·29
Lorenz	105·93

Lorenz value is too low because of the size of the mercury tubes used by him.

VII.—*Roiti and Himstedt.*

$$R = n M \frac{\alpha}{\beta} = n 4 \pi^2 a^2 \frac{NN^1}{L} \frac{\alpha}{\beta}.$$

There is a difficulty in having many contacts, for if the contact does not last all the time supposed, β would be too small, R too large, and the length of column too short. There is also an important correction for the ends, and the assumption is made that the coils are uniformly wound. Another difficulty is the theory of the galvanometer under such discharges.

The resistances were compared with Siemens unit, and in the case of Roiti with one of Strecker's coils.

The results are, Roiti	105·89
,, ,, Himstedt	105·98

VIII.—*Calometric Methods.*

The results by these methods cannot claim any great accuracy.

Having thus completed the review of the methods, we must look at the results.

After what I have said we may, I think, reject all work previous to 1882.

The results of H. F. Weber are manifestly too low, while serious doubts attach to the methods of Roiti and Himstedt. For Weber's first method, the early results of W. Weber and Zollner may be omitted compared with those of G. Wiedemann, while the results given by the method of damping will be sufficiently represented by the work of F. Kohlrausch, who alone of those used this method compared the results with the resistance of mercury directly.

The experiments of Lorenz will not, I think, stand rigid criticism, while, unless I am much mistaken, Lenz, who also used this method, has only published results.

We are thus left with the following list, including the

results only of those who have made both the mercury and absolute determinations:

Lord Rayleigh	106·23
Mascart	106·33
G. Wiedemann	106·19
Rowland	106·32
Kohlrausch	106·32
Glazebrook	106·29
Wuilleumeier	106·27
Mean	106·28

The mean of these is 106·28.

If we take for 100 cm. of mercury in B.A.U. the value ·9535 in Lord Rayleigh's results for the value of the B.A.U. in ohms, we get instead of the values 106·21 and 106·24 the values 106·27 and 106·30.

The mean, then, would be 106·29. If we include the three numbers (9, 10, 11) of the table, we get the value 106·30.

It seems then, to me, that the number 106·30 certainly expresses the true value within one or two in 10,000, and the time has come for carrying the conclusions of the Paris Congress one place further.

The establishment of the new standardising laboratory calls for some authoritative expression of opinion here in England. Are we prepared to express our opinion?

In 1886, the Standards Committee agreed, on the motion of Sir W. Thomson, (1) to recommend for adoption for a term of ten years the legal ohm of the Paris Congress as a legalised standard sufficiently near to the absolute ohm for commercial purposes, and (2) that at the end of ten years the legal ohm should be defined to a closer approximation to the absolute ohm.

The Government took no action on this matter, and the opportunity is afforded us of revising, not in ten years, but in four, our provisional suggestion. Shall we replace the 106 cm. by 106·30 cm.

For my part I should be guided greatly by the amount of acceptance that such a decision would meet with. If Prof. Rowland and Prof. Barker, who was with us in 1886, can tell us that they would agree in recommending the Government of the United States to adopt the same view, and if Prof. Mascart thinks that such a course would meet with the approval of himself and his distinguished colleagues in France, I should be heartily glad of it.

If, on the other hand, they press for further time in order that experiments of a higher degree of accuracy, which can no doubt be attained, though probably at great cost, may be carried out, I should deprecate the committee coming to any conclusion which might pledge them to a number which does not meet with general acceptance.

Discussion.

Prof. Rowland (America) said as one of the members of the United States Commission for the determination of the ohm, the matter was entrusted to him. The Commission consisted of Profs. Barker, Trowbridge, and himself. The experiments were carried on at the Johns Hopkins University, under his superintendence, with a considerable appropriation from the United States Government. The experiments had been going on for many years and they had continued to experiment down to the present time. Indeed the whole matter had been gone over by one of his associates, Dr. Duncan, Professor of Applied Electricity, and he with his students had determined, not only the absolute unit, but also had made a complete determination of the mercury unit. Unfortunately, he could not bring figures as he had been travelling for several months, but they had been gone into, as he had said, very carefully, and if he recollected rightly the number 106·32 had been slightly diminished. Prof. Glazebrook's criticism, however, had been so exhaustive that he could add very little with respect to it. As to which were the best methods there were very few who would dispute that the method of Lorenz was the best for this determination. They had a very definite quantity to measure, the diameter of a revolving disc to measure, which was a very definite quantity, and then, as Lord Rayleigh had shown, the determination could be made so as to almost entirely eliminate the radius effects of the coil. That was the most important feature of the experiment because nothing was undetermined in the experiment of the radius of the coil of wire. They wound the coil in the groove, but as to where the different wires were in that groove it was impossible to determine with any very great accuracy, so if they could eliminate this quantity they could get more accurate results—that was, if it existed. Therefore all experiments which depended on the square of that quantity, as, for instance, when they had a revolving coil, had this source of error, he thought. In his opinion the Commission of the United States would be perfectly willing to recommend the figures so far determined. Those who were connected with the Commission would recollect that the United States never recommended to the Government any figures whatever. The 106 decided on by the Paris Conference was never accepted by the United States even provisionally, and therefore the matter had been left entirely open to the present time, because they felt that English electricians would come to some figure of this sort. They were now prepared in America to recommend the same figure based on the result there given, and he might mention that the Superintendent of the Coast Survey had intimated to the committee that he was willing to establish a Bureau of Electrical Measurement under the charge of his department. He did not suppose they would take up many units, but at least they would take up the unit of resistance, if they had the sanction of the United States Government.

Lord Rayleigh said that it made him feel very antiquated to see his name at the head of the list of 16 determinations of the ohm. He thought Mr. Glazebrook was quite right to begin where he did, because before 1882 the results obtained were comparatively wide. At that time discrepancies of 3 per cent. existed. It was very satisfactory to find that now the whole question was narrowed to one in a thousand instead of three in a hundred. Certainly looking at those figures, and listening to Mr. Glazebrook's able exposition of the methods followed by various observers, it looked very much as if the numbers he (Ld. Rayleigh) obtained for the spec. res. of mercury were a little in error. That number (9541) was higher than those found by recent progress, and the only difficulty he found in accepting it was that he found the observations exceedingly easy to make, and probably he was wrong. But still he was not content with an agreement between the first two or three measurements. The experiments were protracted for a considerable time, and considerable variation was used in preparing tubes, and the degrees of concordance in the results was very great. Certainly at the time he would have thought it extremely unlikely that any repetition could have altered the figure 9541 into 9535, or whatever was thought most probable. At the same time anybody who had had any experience of that kind of work must know that unexpected errors did creep in. Since the publication of Mr. Glazebrook's paper upon the subject, in which to a great extent the same method and even the same apparatus was used as that which he (Lord Rayleigh) employed, he had gone into the matter very carefully in the hope of perhaps finding where the difference lay between them, but he had been unable to find any error in the work which led him to the higher number. The notes of the experiments were nearly complete, and it was as easy to make the calculations now as at the time of the experiments. He could not explain the discrepancy unless there had been a shifting in the standard coils themselves, in comparison with which the mercury tubes were observed. Mr. Glazebrook had shown that if they discarded that number (9541) and substituted for it the recent comparisons of mercury with the British Association unit, then the absolute number that he (Lord Rayleigh) obtained for the British Association unit would lead to very nearly the same results for the length of the mercury column as had been obtained by others. It looked as if the general balance of evidence was in favour of 106·30, which Mr. Glazebrook had taken, although he might be sanguine in supposing that they were confident of it to two parts in 10,000. It was a good many years since he had taken this into account. He had a distinct impression of functions which would represent the manner of divergence. He was not quite sure whether he had rightly understood Mr. Glazebrook, in commenting upon Lorenz's work, to say that he had not taken account of the manner in which a current would enter a wide column of mercury from a wire. At any rate he must have been quite on his guard in that matter. He (Lord Rayleigh) was sometimes inclined to think that a little too much importance was attached to the expression of the resistance of mercury absolutely. Supposing that they could be quite sure the length of the column of mercury was 106·30, what use were they to make of the fact. An electrician in his laboratory did not find it easy to set up a mercury tube and to obtain results by that method. In a factory it would be still more unlikely that mercury would be employed for the purpose. Practically, to make use of the determination, they must have a wire. He was inclined to think the numbers expressing the British Association unit were quite as important as those into which mercury entered. Mr. Glazebrook had explained that a wire was first expressed in absolute measure, and then the comparison was made with mercury. It was very important, no doubt, to make that comparison for standard wires, but it was really the wire that was wanted for practical purposes, and therefore he thought as much importance should be attached to the fifth column of figures as to the last. The only other thing that occurred to him to say was that he did not quite understand why so very much less importance was attached to the determination of the ampere as to the determination of the ohm. They had there a long series of determinations on the subject of the ohm. So far as he knew the received ampere depended upon only two sets of observations, those of Prof. Kohlrausch and himself. It was true it was more difficult to define the ampere than the ohm, but it was as important that it should be defined; and he would suggest to those who still felt inclined to experiment on the subject of electrical units, to repeat the measurement of the ampere, feeling that that was perhaps liable to greater uncertainty than attached to the ohm.

Prof. Barker (America) expressed great gratification at the reception they had met with. He had been struck with the clearness and justness of the statements of Mr. Glazebrook in regard to the matter. It had been placed before them in such a manner that the thanks of the section were due to him. He felt that they occupied an anomalous position in regard to the ohm. When the congress of 1881 determined to submit to experimental determination in the various countries, the work was undertaken on behalf of the United States by their committee under the presidency of Prof. Rowland. The work occupied some time and was made with a great deal of care, in consequence it was not completed when the meeting of 1884 took place. They (the committee) petitioned for a further postponement in order to enable

the results of the American experiment to be presented at the Paris Congress. This, however, was not done. As they all knew, action was taken in Paris upon results which did not include the American observations. Having no part in it, therefore they should be considered to be entirely independent as to whether 106, which was dignified by the name of the legal ohm., although it had never been legalised in England or America, should be still further legalised by England or the United States, or whether what seemed positive knowledge now should not be legalised. As Mr. Glazebrook said, it was fortunate that the English Government took no action in regard to the matter. He (the speaker) attended the meetings of the committee, and he supposed the pressure of having some legalised standard led to the suggestion of Sir William Thomson that 106 should be adopted. At that time probably that figure came up to their knowledge, but now was an opportune time to take legal action. He seconded Prof. Rowland's opinion that the United States would be very glad to adopt 106·3, which the committee of the British Association recommended for adoption as the ohm. It would be also great satisfaction if Prof. Mascart would secure simultaneous action in France in the same direction. They in America were very much indebted to Englishmen for the work accomplished here, more especially to the various committees of the British Association. He might be allowed to refer to another matter scarcely germane to the subject under discussion. It would be remembered that at the Paris Exhibition of 1881 the name of Weber was taken away from the unit of current and the name of Ampère substituted, and the name of Coulomb for quantity. At the time he (the speaker) suggested that the Americans were entitled to some sort of representation, and he suggested the name of Franklin for one of the units, and this was seconded by Prof. Mascart. This, however, was not done, and he wished to say that they would support England in the matter of the units, if it would support them in getting the name of Franklin somewhere.

Sir William Thomson said he was afraid he might be held to be a partisan of 106. He begged to say that he was not, and never was. He thought Mr. Preece would bear him out in that. They fought hard for 106·25 at the Paris Congress, but the case turned out 106 or nothing, and for the whole German scientists and instrument makers to be left to the Siemens unit. The two brothers Siemens, Werner and William, were present, and they very much desired that a mercury unit should be kept, recommending and suggesting very good reasons for keeping it, reasons to which Lord Rayleigh alluded. The mercury unit, then, was adopted, and the question was how many centimetres instead of the Siemens 100 was to be taken for the new unit. Now it so happened that there were no observers present (and there was a considerable number of distinguished men present from Germany and Italy) but no observers whose results went above 106; the average of all the results before the congress came to almost exactly 106. He urged that Lord Rayleigh's were worth all the others put together, and he believed that he persuaded the mass of the congress to that fact, but he could not bring them to the point of voting. When four years ago he proposed the 10 years' period, and that was carried by the British Association, electricians did not live so fast as they did now, and he was only too glad to see that four years had done the work of 10, and he cordially agreed with Mr. Glazebrook, Prof. Barker, and Prof. Rowland, in feeling very thankful indeed that the British Government did not take any action on the resolution of the British Association committee adopted four years ago. He cordially agreed in the idea held now by persons present and many who were absent, that now had come the time for fixing the standard at 106·3. He thought that nearer 106·4. The results were more than 106·2 and less than 106·4. 106·3 was the nearest whole number and was much better than 106. It was within one or two parts in 10,000 of the true value. One word about the British Association method. He did not know that there would be any proposal to go on with any more elaborate methods, but if any more great experiments were to be made, he would just say a word for the British Association method, that they had not yet seen all that it could do. He spoke of that very question with Clerk Maxwell about levelling and sensibility, and it was obvious that the right place to do the experiments was the equator, and he (Clerk Maxwell) was ready to go there and do it; and he (Sir William Thomson) believed that if he had been spared he would have kept that in view. Going to the equator would at once increase the sensibility in the ratio of the horizontal force at the equator to the horizontal force there (in England). It would absolutely do away with all trouble in respect of level. He hoped if any more observations were made the British Association method would be kept in view with that fact that results at the equator would be more accurate than it was possible to get with observations made in Leeds or at Cambridge, where they have been made. He called attention to the remarkable agreement now between the results of several observations obtained with such very different methods. It was quite surprising to find all come so close to 106·3 when they considered the great difference between the methods.

Mr. Preece said he thought to a certain extent he must accept the responsibility of having advised Her Majesty's Government to decline to accept 106 as the legal unit in 1886, and the reasons for that course were very powerful and very numerous. Any change that would have then been made would have meant most serious expenditure. The number of apparatus of all kinds adjusted to the British Association unit, not only in this country, but in the colonies and all over the world, was so enormous that any change made would have been a matter involving a cost of many thousand pounds, and one that would certainly result in another change within 10 years. There was no doubt it would have been wrong then; on the other hand, there was equally no doubt that at the present time they would be perfectly right in making a change. After hearing what had been said on the subject he would not have the slightest hesitation in recommending 106·3 to the Institution with which he was connected as representing the true ohm. They must remember that although it might not be absolutely accurate, it was as accurate as most measuring instruments, in some cases far superior. In reply to Lord Rayleigh's question, Why they did not measure the ampere? the measurement depended not only on the accuracy of the ohm, but also on an accurate knowledge of the measurement of the volt, and when they had the volt represented as accurately as the ohm, then perhaps they might fall back upon the ampere. At the moment the only measurement of the unit E.M.F. was the measurement made by Lord Rayleigh himself, and he did not think that as accurate as the mean results brought before them that day. Although the discussion before them took in view general electrical units, he did not wish to raise any question except on that of the ohm, he wanted gentlemen present and electricians to take into consideration at some future day the entire alteration of the volt. It was a most unfortunate thing that the volt was taken as equivalent to 10^8 C.G.S. units. This had been done because that particular volt and the E.M.F. of a Daniell cell were very closely allied. But if the volt had been made 10 to the power of nine, instead of 10 to the power of eight, then the practical unit of current, the ampere, would have been exactly the same as the unit C.G.S. that was now nearly always used in enquiries, so he felt quite sure that the day was not far distant when all electricians would have to take into consideration the enlargement of the volt, and it would have the benefit of enlarging the other units at the same time. To take an instance, there was the watt. This was too small to use as the unit of power—they had to call it the kilowatt, and because it was called that it did not go down so smoothly as if it had been called the watt. If they raised the volt to 10 to the power of nine they would also raise the watt, then the watt would become very nearly a man-power and $\frac{1}{8}$th of horse-power, and they would obtain a unit of power scientifically accurate, and so closely allied to existing units used by engineers in general that the ridiculous horse-power would be driven out of existence and the watt used instead. With regard to Prof. Barker's suggestion as to the name of Franklin, they all agreed that if it was possible to slip in the name they would, but it was not the only name they wanted to slip in—there was Henry, which had been suggested in America as the unit of self-induction. He could promise Mr. Barker that if any new nomenclature was wanted the names of Franklin and Henry should receive consideration.

ALTERNATING VERSUS CONTINUOUS CURRENTS IN RELATION TO THE HUMAN BODY.*

BY H. NEWMAN LAWRENCE, M.I.E.E., AND ARTHUR HARRIES, M.D.

The present paper is supplementary to a preliminary paper on the same subject read before the Institution of Electrical Engineers on 27th March, 1890. In that paper it was stated (*Society Journal*, vol. lxxxvi., 1890) that "Our experiments have not been made with the powerful currents dealt with in electric lighting and distribution of power"; and this admission, together with the difficulties inseparable from the accurate measurement of alternating-coil currents, are points in connection with our paper which have given rise to much discussion in the electrical and other journals. In the present instance, however, we have endeavoured as far as possible to obviate criticism on these grounds: (1) By using currents directly from lighting circuits, both alternating and continuous. (2) By using currents directly from a dynamo whose rate of alternation could be accurately ascertained. (3) By using currents of high E.M.F. (4) By using an instrument for the measurement of alternating currents whose accuracy at the reading of our former paper was theoretically questioned by one or two speakers, but which has since been tested and proved to give correct readings by an eminent practical electrician (*Society Journal*, vol. lxxxvi., 1890), thus confirming the accuracy of the readings formerly recorded by the instrument, as well as those which are contained in our present paper.

Another practical point to which special attention has been given in this paper is that our experiments have been made chiefly with the skin in a state of nature, so that the conditions of experiment as nearly as possible resemble those which might be expected to exist under accidental circumstances—that is to say, under circumstances when contact with conductors was unexpected, and, therefore, unprovided for. With so much brief preface, we proceed to give in detail the results of several series of observations made under the conditions explained at each step.

Resistance.

In dealing with the resistance of the human body many difficulties present themselves, and render it by no means easy to arrive at definite data thereon. The complicated structure of the body at once prohibits any attempt to regard it as an ordinary inanimate conductor. Several methods have been tried or suggested. The Wheatstone bridge method, which we previously adopted, was shown to be inaccurate by Mr. Otto T. Bláthy, in the *Electrician* of April 25, 1890, and the unsatisfactory nature of comparisons made between resistance measurements taken with the E.M.F. of a few battery cells and those likely to result from the use of an

* Paper read before the British Association.

E.M.F. such as is common in light and power circuits, has been pointed out by several of our critics. We have therefore thought it best to obtain our resistance measurements by passing the current direct from a light circuit through two or more bodies in series, and then, by noting the current strength passed and the E.M.F. used to pass it, to calculate the resultant resistance.

For this purpose we used in the first case dynamo-generated continuous current taken from the lamp leads at the Institute of Medical Electricity, which is supplied by the St. James's and Pall Mall Electric Light Company. Having disconnected a lamp the voltage was tested, and found by a Cardew voltmeter to be 104. We then connected up two metal electrodes of 45 square centimetres area each, which could be grasped in the hand, putting in series therewith only a milliampere-meter having 755 ohms resistance and a key. Two persons joined hands, and each grasped one of the electrodes with his free hand. Circuit was then completed, and the reading taken.

The results are set forth in the following tables:

TABLE A.—*Resistance to Continuous Current.*

Group.	E.M.F. in volts.	Current strength in milliamperes.	Total resistance.	Resistance of milliampere-meter in ohms.	Resultant resistance of each person.
*1	104	7·5	13,866	755	6,555
*2	,,	5·75	18,086	,,	8,666
*3	,,	7·25	14,345	,,	6,795
*4	,,	9·25	11,243	,,	5,244
*5	,,	9·5	10,947	,,	5,096
*6	,,	8·0	13,000	,,	6,122
*7	,,	10·0	10,400	,,	4,822

* Two persons. Average, 6,185 ohms.

In the second case we used a dynamo-generated alternating current taken from a Siemens dynamo at the School of Electrical Engineering, Hanover-square, which was kindly placed at our disposal by the managers (Mr. Wm. Lant Carpenter and Mons. Leon Drügman). The arrangements for connection were exactly the same as those described above for the continuous current, except that groups of four and five persons joined hands, instead of only two. The same Cardew voltmeter, the same milliamperemeter, the same electrodes were used.

The voltage varied from 115 to 137, and the alternations from 60 to 75 per second.

TABLE B.—*Resistance to Alternating Currents.*

Group.	E.M.F. in volts.	Current strength in milliampere.	Total resistance.	Resistance of galvanometer.	Resultant resistance of each person.
1. 5 persons	115	4	28,750	755	5,599
2. ,,	120	5	24,000	,,	4,649
3. ,,	123	7	17,571	,,	3,363
4. ,,	124	7	17,714	,,	3,391
5. ,,	124	6	20,666	,,	3,982
6. 4 persons	123	8	15,375	,,	3,655
7. ,,	137	9·5	14,421	,,	3,416

Average, 4,008 ohms.

These observations show results widely differing from those obtained by other methods, and indicate that while under these conditions the resistance to the two forms of current more nearly approximate to one another, yet that to continuous current is still considerably greater than that to alternating. It is interesting to note that the average resistance to alternating current obtained by this method closely corresponds to that obtained by Mr. Bláthy, and mentioned in his letter above referred to. He makes from it 4,000 to 5,000 ohms, and our results show an average of 4,008 ohms. We may state then, in round figures, that we find the resistance of the human body, under the conditions named to continuous current, to be 1·5 times that to alternating current.

We next endeavoured to find how far variations of the contact area would affect the result, and obtained the following readings:

TABLE C.—*Variations in Current due to Alterations in Contact Area, E.M.F being Constant.*

(Continuous dynamo current at 104 volts.)

Total contact area in square centimetres.*	Current strength in milliamperes.				
	Sub. 1.	Sub. 2.	Sub. 3.	Sub. 4.	Average.
00·0	10·0	10·0	10 0	10·0	10·0
45·0	7·25	5·25	7·0	5·25	6·19
22·5	6·0	4·75	5·75	...	5·5
†9·0	5·75	3·25	4·0	...	4·3

* Two electrodes each having same area, one being grasped in each hand.

† Electr des held by thumb and finger only.

From this it appears that, in round numbers, a reduction in the contact area of 50 per cent. reduces the current strength by 40 per cent., a reduction in the contact area of 75 per cent. reduces the current strength by 45 per cent., and a reduction in the contact area of 90 per cent. reduces the current strength by 60 per cent.

It is manifest that to arrive at anything like a definite law on the subject a great number of readings must be taken, but we think the above results form a useful indication of the important bearing contact area has in determining the seriousness or otherwise of accidents in light and power circuits.

Sensation.

In this part of our paper we propose to compare the results obtained when electrodes connected respectively with dynamo-generated continuous currents and dynamo-generated alternating currents are brought into and kept in contact for an appreciable time with the human skin in a natural state—that is to say, in the state normal to the person experimented upon at the time of testing. In order that this series might be complete, it might possibly have been better to give barometric, thermometric, and hygrometric readings, of which we have taken many, but these data belong rather to a complicated side issue, and do not affect the main question to which this paper must necessarily be confined, so we have considered it best to omit them altogether, taking it that the subjects experimented on were in an average condition of health at the time, and that the atmospheric conditions were more or less like those to be expected in a climate similar to that of England.

The results are tabulated as follows:

TABLE D.

Conditions.—Metal handle electrodes grasped in the hands (surface area 45 square centimetres each), in connection with dynamo-generated continuous current, taken from lamp lead as before mentioned (Table A).

E.M.F. 104 volts by Cardew's voltmeter.

Subject.	Discomfort point.	Fixation point.
	Milliamperes.	
1	18	not any.
2	15	not any.
3	20	not any.
4	22	not any.
5	15	not any.
6	20	not any.
	Average, 18·3	

In each instance burning sensation under the electrodes became unbearable after about 30 seconds; this was the only objectionable feature, though electrolytic action was sufficiently marked to induce slight blistering in two of the cases. We have to call special attention to the fact *that in no case was muscular fixation, or any sensation approximating thereto, reached with the continuous current*, nor have we at present any reason to suppose such a result possible.

TABLE E.

Conditions.—Metal handle electrodes grasped in the hands (surface area 45 square centimetres each).

Alternating Current from Siemens dynamo.

E.M.F. 110 volts, by Cardew's voltmeter.

Number of Alternations per Second, 23.

—	Current strength.	
	Discomfort point.	Fixation point.
	Milliamperes.	Milliamperes.
1	3·0	6·0
2	3·5	7·25
3	4·5	6·5
4	3·5	8·5
5	4·0	7·25
	Average, 3·70	Average, 7·10

TABLE F.

Alternating Current from same dynamo as last table.

Electrodes as last table.

E.M.F. 85 volts.

Alternations per Second, 68.

Subjects as before.	Current strength.	
	Discomfort point.	Fixation point.
	Milliamperes.	Milliamperes.
1	3·5	6·0
2	4·5	8·75
3	3·75	8·0
4	4·75	8·75
5	4·25 not reached at	8·0
	Average, 4·15	Average, 7·90

manufacturers of and dealers in copper and other metals, and all metallic alloys or compounds of the same, and all goods and articles made of copper or other metals and alloys; to carry on the business of supplying electricity in all its branches, and in particular to erect or acquire any works or other structures requisite or convenient for the purposes of the companies, and to carry on the business of electricians, electrical contractors, electrical mechanical engineers, and suppliers of electricity, and of manufacturers and dealers in all apparatus required for or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. The first subscribers are:

	Shares.
A. L. Broekman, 8, The Avenue, Brondesbury	1
T. E. Marsh, 42, Reighton-road, Clapton	1
G. Neath, 88, Queen-street,	1
S. Rentell, 121, Vassall-road, Brixton	1
J. Mumford, 50, Trinity-square, S.E.	1
J. Moore, 46, Norroy-road, Putney	1
F. D. Summers, 31, Berwick-street, S.W.	1

There shall not be less than three nor more than nine Directors; the first to be appointed by the subscribers to the memorandum of association. Qualification, 200 shares; or stock of the nominal value of £500. Remuneration: Chairman, £400; Vice-Chairman, £300; other Directors, £200 each, together with 2½ per cent. upon the net profits made from manufacturing, and upon the revenue accruing from licensing or sub-licensing the Company's patents, and 1 per cent. upon the net profits made from sales of patents, licenses, or business, such commission to be divisible as they may think fit.

PROVISIONAL PATENTS, 1890.

SEPTEMBER 8.

14077. **Automatic transmitter for submarine cables or long telegraph lines.** Thomas James Wilmot, 154, St. Vincent-street, Glasgow.

14090. **Improvements in oil cans especially adapted for use on electrical installations.** Alfred James Jarman, 11, Furnival-street, Holborn, London.

SEPTEMBER 9.

14155. **Improvements connected with switchboards for telephonic systems.** Harry Thomas Ogilvie Fraser and James Wallace Brown, 47, Lincoln's-inn-fields, London.

14156. **Improvements in electrical alarm clocks and watches.** Henry England, 8, Quality-court, London.

14168. **Improvements in tools for the making of splices in submarine and other telegraph cables, ropes, and cables.** Frederick Frasi, 10, Langton-terrace, Shooter's Hill-road, Blackheath.

14181. **An improved electrical fog signal for railways, etc.** William Andrews, 116, Hunger Hill-road, Nottingham.

14182. **Improvements in or connected with telephonic switching apparatus.** Harry Thomas Ogilvie Fraser and James Wallace Brown, 47, Lincoln's-inn-fields, London.

14186. **Improvements in electric switches.** Charles George Perkins, 151, Strand, London. (Complete specification.)

14191. **Improvements relating to electric railways.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

14193. **Improvements in means or apparatus for controlling, regulating, or automatically interrupting, and indicating electric currents.** Rudolf Langhans, 47, Lincoln's-inn-fields, London.

14196. **Improvements in incandescent electric lamps.** William Robert Lake, 45, Southampton-buildings, London. (John Bleecker Tibbits, United States.)

14197. **Improvements relating to the use of electric motors and to the regulation or control of machinery operated thereby.** William Robert Lake, 45, Southampton-buildings, London. (The Thomson-Houston International Electric Company, United States.) (Complete specification.)

14202. **Improvements in apparatus for receiving payments, and for permitting the use of telephonic apparatus in exchange therefor.** William Robert Lake, 45, Southampton-buildings, London. (Paolo Bonamico, Italy.)

14204. **An improved electric miners' safety lamp.** George Collins Levey, 1, Queen Victoria-street, London.

SEPTEMBER 10.

14232. **Improvements in magnetic circuits of dynamo-electric machinery.** Rankin Kennedy, 10, Justin-street, Kilmarnock. (Complete specification.)

14255. **Improvements in or relating to the method of generating, transmitting, storing, and distributing electrical energy, and apparatus therefor.** William Lowrie and Charles James Hall, 433, Strand, London.

14260. **Improvements in electric or magnetic carrier systems, otherwise known as port-electrics.** Herbert John Haddan, 18, Buckingham-street, Strand, London. (John Thomas Williams, United States.) (Complete specification.)

14269. **Improvements in electrical signalling apparatus, for police service and the like.** Robert Dunbar Radcliffe, 45, Southampton-buildings, London. (Complete specification.)

SEPTEMBER 11.

14313. **An improved electric fog signal for railways.** Robert Aldridge, 9, Oak-cottages, Bowes-road, Palmer's Green.

14341. **Improvements in electrical apparatus for reproducing sound.** Jules Ernest Roulez, 47, Lincoln's-inn-fields, London.

14349. **An improvement in electric meters.** Siemens Brothers and Co., Limited, 28, Southampton-buildings, London. (Siemens and Halske, Germany.)

14368. **An automatic electric lighting contrivance for staircases** Ludwig August Thranitz, Temple-chambers, London.

SEPTEMBER 12.

14393. **Improvements in and connected with electrical apparatus for recording the presence of watchmen, workmen, or others.** William Lucas and Thomas Alexander Garrett, 128, Clerkenwell-road, London.

14394. **Improvements in electric bells.** Frederick William White and Ernest Frank Furtado, 4, Great Winchester street, London.

14404. **Improvements in electrical switches.** Charles Scott Snell, Culver Park, Saltash, Cornwall.

14411. **Improvements in secondary batteries.** Job Thomas Niblett, 6, Bream's-buildings, London.

SEPTEMBER 13.

14433. **Improvements relating to coin-freed electrical apparatus.** Arthur Ford Lloyd, 29, Chesterfield-grove, East Dulwich.

14459. **Improvements in electric bells or sounding apparatus.** Edmund Edwards, 35, Southampton-buildings, London. (Gabriel Bénard, France).

14460. **Improvements in electric bells.** Edmund Edwards, 35, Southampton-buildings, London. (Gabriel Bénard, France.)

14482. **An improved connection for electroliers or electric chandeliers.** Richard Brown Evered and Thomas Rudling, 45, Southampton-buildings, London.

14484. **An improved combined electric switch and connecting or coupling device.** Richard Brown Evered and Thomas Rudling, 45, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1889.

13168. **Electric lamps.** McCandlish. 6d.

13510. **Electric lamps.** Lawrence. 8d.

15787. **Recording instruments.** Drake and Gorham. 6d.

16537. **Insulators for electric wires.** Rylands. 8d.

17387. **Electric meters.** Oulton and Edmondson. 8d.

1890.

7871. **Electric signal circuits.** Hart. 6d.

8652. **Magneto-telephone systems.** Greene. 8d.

11025. **Dynamo-electric generators.** Johnson (Higham Patent Right Company). 8d.

11045. **Printing telegraphs.** Taylor and Leavens. 1s. 1d.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the week ended September 12 amounted to £4,728.

West India and Panama Telegraph Company.—The estimated receipts for the half-month ended Sept. 15 are £2,384, against £2,038.

Direct Spanish Company.—The Directors recommend the payment of the dividend at the rate of 10 per cent. on the preference shares, and at the rate of 6 per cent. on the ordinary shares, for the half-year ended June 30 last.

Western and Brazilian Telegraph Company, Limited.—The receipts for the week ended September 12, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,698.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	1¾
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	8

NOTES.

Paris Lighting.—Some large amalgamations of the various electric lighting companies in Paris are expected.

Electric Cremation.—MM. Delahaye and Bouchet have taken a patent for an electric furnace for the rapid incineration of human remains.

Fire in Electric Works.—We are desired by Messrs. Cathcart and Peto to state that the recent fire at their Hatton-garden works will in no way interfere with their business.

Electric Power Rates.—In our issue of August 22 we gave the list of prices for electric power adopted at Baltimore. As the question has been asked, we may state that these rates are per month.

Alternating System in America.—According to the list of the Westinghouse Company, since 1887 they have put down 301 alternating current stations, with a total generating capacity of 554,350 lamps of 16 c.p.

Injectors.—We have received the catalogue of Messrs. Holden and Brook, Limited, of Salford, dealing with exhaust and live steam injector practice, and containing a series of self explanatory drawings of the latest types of injectors with instructions for use.

German Electrical Paper.—We have received a copy of a new German electrical paper, the *Elektricitats Zeitung* ("Electricity Gazette") of which Mr. Arthur Wilke, until now associated with the *Elektrotechnische Anzeiger*, will take the direction from October 1.

Electro-Harmony.—The concerts of the Electro-Harmonic Society will recommence on the 3rd October, and will be continued on November 7th and December 8th, 1890, and January 30th, February 27th, and April 10th, 1891. They will be, as before, held in the Banquet-room, St. James's Hall Restaurant.

Bromley.—The Bromley Local Board have raised an objection to either syndicates or private speculation establishing the electric light by means of advertising it in the town, and they have unanimously resolved to apply for powers themselves. The clerk has been instructed to take the necessary steps for obtaining a provisional order.

Quick Tramcar Building.—They do not take long to put things through in the street railway line in America nowadays. We see that the John Stephenson Company have constructed and forwarded six electric cars, with wire, trolley gear, and motors attached for the street railway at Elmira, within 23 days from date of booking the order.

Holborn Town Hall.—The Holborn Committee of Works recommended that the electric light be supplied to the whole of the public rooms and offices in the Town Hall, Holborn. The clerk was directed to communicate with the Metropolitan Electric Supply Company to ask if they were prepared to supply the light, and, if so, upon what terms.

Frankfort Exhibition.—We are kept informed from time to time of ideas promulgated or plans projected for rendering the Frankfort Exhibition more interesting and representative. One of these projects now determined upon is that of a captive balloon worked by electricity, and inflated, moreover, by pure hydrogen obtained electrolytically.

Extinguishing Fires by Electricity.—In the N.Y. *Electrical Engineer* for September 3, Mr. H. L. Lufkin has an article descriptive of a system of extinguishing fires by electricity, by which the fire is indicated electrically. A motor is started, water is pumped, and the sprinklers open at the right place, all automatically and by the aid of the electric currents. This system is specially designed for theatres and public buildings.

Fire in the Popp Conduits.—On Thursday last week, about seven in the evening, the lamps on the Popp circuit in Paris suddenly went out, and opposite one of the lamps a fire broke out in the underground conduit in the centre of the roadway, between the Rue Daunou and the Rue des Capucines. An explosion was greatly feared, but fortunately did not take place, and the workmen were able to extinguish the fire and put the mains in order within two hours, during which time the street was in darkness.

Birmingham Electric Cars.—Electric cars are both appreciated and the reverse in Birmingham. Complaints are made in the local papers of several little matters requiring attention. Besides a want of punctuality, it is stated the drivers are too chary of stopping to pick up passengers, even at fixed calling places; that the seats are not kept dry outside, and that there is no communication between outside passengers and the conductor. These are little matters which are thought might be attended to to achieve thorough satisfaction with the new tramway service.

Swansea.—The Borough Surveyor of Swansea has just returned from a series of visits to various towns which are lighted by electricity, and has presented his report to the Town Council. Several tenders from electrical engineering companies have been received, and one of these is recommended for acceptance. The amount is £200 over that paid for gas, but it is pointed out that thirteen times the power of illumination will be provided for this sum. It is proposed at first to light only the centre of the town, and on the success of this will depend the general adoption for street lighting in Swansea.

Telegraph Difficulties.—In the military despatches on the Chin-Lushai operations, mention was made of the excellent work done by the telegraph department, but the civil officers engaged deserve yet further notice, for their labours were of the most trying kind. Field lines of a length of 420 miles were laid, the principal section being from Demagiri to the Upper Koladyne, 104 miles, and from Pouk to the Boinu river, six miles west of Haka, 192 miles. Mr. E. O. Walker laid the former section, and the difficulties he had to overcome were very great, the line running through a dense forest and across a succession of hills from 2,000ft. to 5,000ft. in height.—*Indian Engineer.*

Topeka.—The water power dam to be built at Topeka, Kansas, for the distribution of electric light and power, according to *Engineering News*, is to be put under construction about October 1st. It will be built on a concrete base, faced with masonry to the water level, and from there up of masonry alone. It will be 771ft. long, 29ft. 4in. wide at the base, 6ft. wide at the top. On the south side a flume of masonry 80ft. wide and 200ft. long will be constructed, in which will be placed the turbines. In the construction of the dam it is proposed to put in six buttresses, which can be used as piers for a bridge if desired. The contracts for the masonry and electrical and water power machinery will be let soon.

Utilising Niagara.—There seems to be business meant this time about the Niagara scheme if we are to believe the reports just to hand. The Cataract Construction Company have awarded the contract to Rogers and Clement, promi-

nent New York contractors. The exact amount is not known, as the matter was to be kept secret and only leaked out by being talked about by unsuccessful bidders; but the papers, including the bond of contractors for 300,000 dols., are undoubtedly in preparation, and probably are signed by this time. The tunnel is a mile and a half in length, and will be one of the biggest, as it is certainly one of the most interesting, contracts undertaken. The franchise is held on the proviso that the work is completed by January 1, 1892.

Church Service by Telephone.—A new experiment with the telephone is to be made in Birmingham on Sunday. Transmitters will be set up in Christ Church, New-street, so that subscribers to the telephone, if they desire, can hear the service and the sermon at their private residences. The general manager of the company has been encouraged to make the trial by the success which attended a similar scheme initiated by him eight years ago at Bradford. At the end of the choir stalls, on the top of the lectern and the reading desk of the pulpit, small metallic-cased transmitters will be placed, and they will be so regulated that sound will be gathered in without requiring the voice to be directed in close contiguity upon the plate of the transmitter.

Leeds Corporation.—At a meeting of the Leeds Electric Lighting Committee on Monday, the sub-committee appointed by the Council in July last to obtain further information as to the system of electric lighting in operation throughout the municipalities of the country presented its report, and after discussion it was agreed that this should be submitted to the Council at its next meeting. It will be remembered that when the Council received the committee's recommendation a few months ago to apply for a provisional order to the Board of Trade for powers to institute an electric lighting scheme, it was thought desirable that more information should be obtained. This will be in the hands of the Council in a few days, and the question of whether the Corporation should undertake the work or leave it to private enterprise will again come up.

Electric Tramcar Accident.—A terrible accident, says the Rome correspondent of the *Daily News*, happened on Tuesday in Florence, and has interrupted the festivities there. A car of the new electric tramway between Florence and Fiesole, coming down hill at a terrific speed, ran off the rails, and hitting against a wall was overturned. Six persons were killed on the spot, and over 20 wounded. It seems that the accident was caused by a mistake of an inexperienced driver, who, instead of closing the regulator on coming down hill, increased the speed by turning it the wrong way. The driver, although badly hurt, was arrested, and the crowd has prevented all the other cars from running. As soon as the King was informed of the accident, he hurried to the hospital to visit the wounded. Their Majesties have countermanded the gala representation at the Pergola Theatre.

Alternators.—The idea that the new alternator devised by Prof. Elihu Thomson is practically the same as that made by Mr. Mordey three years ago, is strongly demurred to by the *Electrical World*, which maintains that it is far less like the Thomson machine than several other forms that might be mentioned, and says: "In the general principle of rotating, a group of poles of similar polarity before another group of opposite polarity, the whole being magnetised by a single set of coils, it bears no resemblance to the particular machines to which our English friends have referred. It is a very difficult matter in the present state of the art to design a machine which cannot be accused by somebody of being remarkably similar to some previously known form; but it would be difficult to find a dynamo of any promise in practical performance of which this could be said with less truth than of the machine in question."

Thomson-Houston Cars for Leeds.—So the Thomson-Houston Company are intending to tackle the question of electric traction in England, after all, without their big company. At least, so it appears. We see that the project which has been before the Tramways Committee of the Leeds Corporation is that of the Thomson-Houston system, and a representative has been explaining the advantages to the worthy councillors of Leeds. The local press has a large illustration of the cars, and discusses the advisability of the introduction of overhead wires down the streets; and describes the arrangement of the cars and gearing. The proposal is to lay down the plant within three months at the company's expense, and when the experiment shall have been fully tested that the Corporation shall have the option of future purchase. If the Corporation see fit to accept this offer, the line will be the first overhead system for English towns. The committee seem not unwilling, but the question of unsightliness or otherwise of the poles and conductors is, as would be expected, the crucial point of the scheme.

The Watkin Tower.—Nothing much has lately been heard of the proposed huge tower for London, for which designs were exhibited some months ago, and destined by Sir Edward Watkin to eclipse the far-famed Eiffel Tower. But if we are to believe the statement of a London press correspondent, the preliminary details are all settled, and the capital is assured. The Watkin Tower is to be erected at Wembley Park, near Harrow, where an estate of 150 acres has been purchased by the company, and a new railway station is already being built. The construction of the tower is to be begun early in the new year and to be finished within eighteen months—which, notwithstanding its greater size, will be six months less than that taken for the Parisian tower. Wembley Park is to be laid out as pleasure grounds, with exhibition buildings, concert hall, and switchback. Of course, if this is so, we may expect to see the plans completed with a very liberal display of electric light, both arc and incandescent; and intending contractors would do well to make enquiries as to the proposed extent of this part of the work, and exercise their ingenuity in the best suggestions for what would promise to be under these circumstances an exceedingly popular resort.

The Berrenberg Vacuum Pump.—Lamp manufacturers were interested a few months ago to read of the new Berrenberg mechanical vacuum pump devised for the rapid exhaustion of incandescent lamps. A remarkable record is given in the *Electrical World* of a group of six 52-volt lamps of 16 c.p. exhausted by this pump, which is now, it may be well to mention, the property of the Beacon Vacuum Pump Company, of Boston. The lamps tested were burned three volts over normal pressure, with the following results: First, 888 hours; second, 960 hours; third, 1,182 hours; fourth, 1,564 hours; fifth, 1,704 hours; sixth, 2,753 hours. This speaks well for the results obtained by the Berrenberg pump, as, without the most perfect vacuum, lamps cannot attain such length of life, especially when burned over their normal voltage. To still further illustrate the beneficial effects of a non-mercurial

vacuum on incandescent lamps, it is stated that two 16 c.p. lamps of 52 volts, exhausted on the Berrenberg pump, were burned on 110-volt circuit, each lamp taking the whole voltage. The lamps developed 750 c.p. each. One of them burned in this way for 45 minutes, and the other actually lasted for 1¼ hours before burning out. Lamps with ordinary mercurial vacuums under this test burned out at once.

Electric Horse Racing.—Those of our readers who are interested in the electric horse racing apparatus that we mentioned some months ago, will find more information about it given in *La Nature*, and a translation, with the same illustration, is given in the *Scientific American* for Sept. 6th. Each hobby horse is mounted on bicycle wheels, the axles inclined to the centre, and one only connected to the electric motor. The motor is placed in a cage on the hind axle, and the current is communicated by connection to rollers through a slot in the floor. The speed of the various horses on their concentric courses is regulated by an attendant with switch and resistances; the mean speed is 13ft. per second, and reaching up to 22ft. per second without danger of derailment. Betting is often made upon them, their running being arranged to be a matter of chance. They are all started and run at full speed till fairly distributed, and then the current is turned off, and they are allowed to run by virtue of acquired velocity, stopping successively on various positions in the course. The horse that stops nearest the goal, but not beyond it, wins the race. The success of the course at Nice last winter was such that Mr. Salle, the proprietor, intends to construct a larger model, which will form one of the attractions of the Exposition of Science and Arts, to be opened next August at the Palace of Industry in Paris.

Ornamenting Brasswork.—Several years ago Mr. Alexander Watt, in one of his papers on the electrolysis of metallic salts, suggested an improvement in connection with ornamental brasswork, which consists in depositing copper electrolytically upon certain portions of the work, leaving the remaining surfaces of the brass in the natural colour of the alloy, the contrast between the pink-red hue of the copper and the yellow metal producing a very pleasing effect. The idea appears to have been somewhat extensively adopted for some classes of brasswork, and might with advantage be applied to electric light fittings, as electroliers, brackets, etc. Mr. Watt informs us that the following formula will be found useful for a coppering bath for brass: Sulphate of copper, ½lb.; oil of vitriol, ½lb.; and water, one gallon, worked with a copper anode, using a current of four or five amperes. In cases where it is desired to produce a brown or black stain on certain parts of a brass article, as in scrollwork, for example, this may be effected by brushing over such parts, after they have been electro-coppered, with a solution of sulphide of barium (five grains to 1oz. of water), the article being well rinsed after the desired effect is produced. The whole piece of work may finally be protected from oxidation by means of a colourless lacquer; or, if preferred, such lacquer may be applied to the coppered surfaces only, the brass parts being treated with the ordinary lacquer.

Loading Storage Cars.—As the accumulator cars extend, one of the principal problems to be dealt with is that of the easiest and cheapest way of changing the accumulators. In the Barking-road cars this is done by shifting the cars along and pushing the cells in on trays. In the Birmingham line a special and well-thought out device is adopted of an hydraulic lift, which raises the various sets of cells to the level of the car from a kind of underground cupboard, and the cells are then pushed into the cars. In the Chamberlain storage car system in America this lifting of the cells has been arranged to be done by a series of lifts, all worked by a small electric motor by means of belting. The cells are thus brought successively to the level of the cars, or raised higher and automatically brought into contact with the charging current. In still another case in America (that of South Brooklyn, carried out by the River and Rail Electric Company), the loading of the cars is done by trolleys of a special make. These trolleys fit the tram lines, and can be pushed about by the workmen. They are fitted on top by a sliding tray, which can be shifted bodily to one side, like a planing machine, by means of a chain and toothed wheel with crank handle. On this the cells are placed, and the trolley run up to the empty tramcar; the crank handle is turned and the whole tray of cells is shifted bodily into the car. A discharged set can be pulled out in the same way, and run along into the depôt to be charged again.

Electric Lighting of Free Libraries.—Mr. W. H. Greenhough, public librarian at Reading, recently read a paper on "Free Libraries," in which he refers to the use and cost of the electric light. "Our experiences," he says, "at Reading on this matter may be of some interest. The contract between the Library Committee and the Reading Electric Lighting Company specifies that the sum of £80 per annum shall be paid for supplying the current to the eight arc lamps in use in the library and reading-rooms, for providing the necessary carbons, and for keeping the lamps in order. The arc lamps in operation at Reading are nominally of 1,200 c.p. each. Some 50 to 60 per cent. of the illumination is, however, absorbed by thick opal globes, which are not only necessary in order to protect the eye from the acute and dazzling rays, but also because, by their use, the light is admirably diffused, and heavy shadows prevented. The total illuminating power at the library is, therefore, equal to about 4,320 candles. The cost for the gas consumed in the library and reading-rooms last year was £79 odd, while the total illuminating power was equal to some 1,360 candles. The result of our experience at Reading with electric arc lighting demonstrates the fact that this method undoubtedly is excellent for the purpose of illuminating lofty rooms, yet the flickering and occasional failure of a lamp to light, from one cause or another, shows that the system is not perfect." To the latter remarks by a critical user of their light electrical engineers would do well to give a little attention.

Fareham.—The following details are given of the lighting of the town of Fareham, now the third town in England publicly lighted entirely by electric light. The lighting is on the Thomson-Houston system, with overhead conductors, on tall poles carried down the principal streets. The two chief streets, with the united length of one mile, are lighted with 21 Thomson-Houston arc lamps of 1,200 nominal candle-power, or with globes of about 900 actual candle-power. The streets are everywhere so light that good print can be easily read at any part of them. The other streets of the town are lit by incandescent lamps of 20 c.p. each, and by arrangement with the Local Board are placed at every point where a gas lamp was situated. For the public lighting about 12 miles of wire, insulated with okonite, are used. A further set of wires will shortly be run for the purpose of private lighting. The central station is a long building of brick, with the part containing the dynamos matchboarded, in order to keep out damp. It

contains at present one engine and boiler and two dynamos—one for the arc lights and one for the incandescent. The installation has been carried out by Messrs. Laing, Wharton, and Down, the boiler and engine being furnished by Messrs. Ransomes, Sims, and Jefferies, of Ipswich. The light was first publicly displayed on September 1, and has been running every night since. Three or four interruptions, at first experienced due to slipping of the belt and heating of bearings of the new machinery, have now been overcome, and both machinery and lamps work beautifully. The lamps, it is said, form quite an attraction each night to the country round, parties being made up to come in and see the lighting of the streets of Fareham. The company have entered into an agreement with the local authorities to light the town for three years for £500 a year, and give an average of eight hours' light every night all the year round.

Incandescent Lamps of High Efficiency.—Some time ago we mentioned the trials that were reported upon an incandescent lamp taking only half a watt per candle-power. We believe that experiments were carried out at this efficiency, and though five or six hundred hours was attained, yet the desideratum of 1,000 hours' life was not achieved. Other trials are now, we are told, in progress near London with one watt per candle-power with greater show of progress, and we are promised detailed reports at a future date. Meanwhile, the following account will show what the American lampmakers are doing in the same direction. "An extraordinary advance," says the account, "is claimed for a new lamp, which will shortly be placed upon the market, and which is now being tested for the inventors by the National Engineering Bureau, of Chicago. A life test has been commenced of the new lamp, which, it is stated, absorbs in no instance more than two watts per candle in the small sizes, the larger sizes being even more efficient. A 300-c.p. lamp has been burning with an efficiency of 1¾ watts per candle, which brings it into direct comparison with arc lamps for efficiency. Commercially successful lamps of 200 volts can be made. A comparative test is now progressing on a 50-volt circuit, and the statement is made that this new lamp is only using nine-tenths of an ampere, whilst the least amount of current absorbed by any of the others is 1·06 amperes, the candle-power measured on the photometer being the same in all cases. The lamps on this test have now been running 200 hours without the slightest depreciation in the appearance of the new lamp. In taking the readings three different styles of ammeters and voltmeters are employed, and the readings are noted by the managing engineers of the bureau and several responsible college professors. It is needless to say that if these lamps fulfil in practice the claims which are made for them, they will work many changes in the present methods of distribution of incandescent lighting." It will be seen from these various reports that attempts are being made to increase the efficiency of the distribution at the actual point of distribution, which, as far as may be judged, seem to promise a substantial increase in output of light for the same original energy. It is to be hoped the promises will be fulfilled.

The Electrical Production of Caustic Soda.—The principal chemicals used by paper manufacturers are caustic soda and chloride of lime, or bleaching powder, and these two substances constitute items of considerable expense in paper mills. For some time past it has been hoped that these two chemicals would be obtained directly and economically from common salt by the aid of electricity. Many attempts, says the *Times*, have been made in the past to effect this object, but we believe they have all ended in failure. This has probably been due to one or the other of two causes—namely, either a deficient knowledge of the laws regulating electric currents or badly-constructed tanks and apparatus for effecting the decomposition economically. The practice has been to separate the products of electrolysis by porous plates or diaphragms, which offer considerable resistance to the passage of electricity, and add to the general cost of useful work done, and are in other respects objectionable. At length, however, it would appear that caustic soda and bleaching powder can be, and indeed are, being practically and economically produced from common salt by the aid of an electric current. This desirable end has been attained by Mr. James C. Richardson, of 23, Claremont-square, London, whose process has been in operation on a working scale for several months past at one of the largest paper mills in the kingdom. The whole apparatus is automatic, the salt solution passing regularly and the caustic soda being drawn off at any strength up to 10 or 12 per cent. pure caustic soda. The chlorine, which can also be used direct for bleaching, is absorbed by slaked lime, and bleaching powder is thus produced. We are not at present at liberty to give any details respecting this process, but we may mention that it is not simply a method of producing a bleaching solution by electrolysing salt, but a commercial process of producing these two important chemicals. The porous partitions are altogether dispensed with in Mr. Richardson's apparatus, and in other respects it differs materially from that employed in previous attempts to effect the same object. It is stated that the cost, both electrically and commercially, is much below that of the ordinary Leblanc process of alkali manufacture, and that at least three times the amount of chlorine is available from each ton of salt decomposed as against that process. Thus a larger quantity of bleaching powder is produced, and the purity of the caustic soda ranges very high. The erection of enlarged plant is being proceeded with at the works where it is already in operation, and the adoption of plant is contemplated at the works of a few other leading paper manufacturers.

The Spectro-Lantern.—A year or so ago mention was made of a novel and ingenious invention in optical telegraphy by Paul La Cour, of Denmark. The apparatus obtained a first-class medal at the Copenhagen exhibition, and at the time attracted considerable attention among scientific and practical circles. It has recently been perfected for actual working, and is made in lantern form by Messrs. Th. A. de Neergaard and Co., of Cophenhagen, under the name of the spectro-lantern, and is worthy of serious attention by those who deal in telegraphic and maritime matters. The apparatus is intended to render practical a method of telegraphing direct by light in Morse signals. It depends for its action upon the fact that white light, consisting of the colours of the rainbow, can be cut up by prisms in a lantern into these colours, forming the well-known bands of the spectrum. By a suitable and carefully-arranged system of screens and prisms these luminous spectrum bands can be given a certain form, which may be made to correspond with the long and short dashes of the Morse code. When, therefore, the light from the lighthouse lantern is observed from a distance through a telescope fitted with a prism, the light appears to consist of these signals, and can be so read by an experienced Morse operator. For the sending of a connected telegram a movable disc is passed in front of the lantern, this disc

being provided with openings corresponding to the letters of the telegram, which are thus read off on the telescope as Morse characters. The spectro-signalling lantern is intended for use between different vessels on the one hand, and between ships and the shore on the other. It is already used experimentally in the Danish marine, and is made to give four distinct signs, which correspond to the flag signals of the International Code, which can also be employed at night time. A different kind of lantern to the above is the lantern having a strongly coloured light suitable for harbour lights and on board ships. By placing the lantern in various positions, the various colours of the rainbow can be seen, and this light is easily distinguishable from the usual red, green, and white lights. The telescope for this form of lamp is, of course, not needed. A lantern of this type has now been in use for nearly a year at the principal entrance to the port of Aarhus, in Denmark, and excellent testimonials have been given as to its advantages. When the spectro-lantern is fully developed it may be expected to come into extensive use. It requires no clockwork, rotatory glasses, and similar costly and breakable apparatus which easily get out of order, but consists of only a lamp and strongly fixed glasses.

Edison's Molecular Electric Generator.—The boiler-engine combination is the bugbear of electrical engineers. If they could do without it they would be happy. It is an unstable kind of servant, requiring constant attention, and wasteful to a degree. While the dynamo yields 80 or 90 per cent. of the theoretical energy, the engine and boiler efficiency remains at some 10 per cent. only. Electricity from heat, therefore, is the goal that progressive electricians look for, not without misgivings as to whether it will ever get beyond the experimental or research stage in the days of their own lives. Thermopiles they have seen tried, but as yet not much seems to come from that direction. Edison, we are told, has determined to solve the question, "if it takes me five years of my life." Well, something has evolved from this study, and we are given a new—an entirely novel—kind of electric generator, which, if it does not generate electricity direct from heat, at any rate, so far as it goes, does away with the boiler and engine combination, and may therefore be said to generate direct. It is not difficult to understand the action of this new generator. It depends on a few plain principles, as follows: (1) That the resistance of air to magnetic lines is 1,200 times that of iron; (2) from this the well-known fact that it is far more difficult to separate faces of iron in contact than at the distance even of the thickness of a sheet of paper; (3) that this difficulty is due to a difference of the number of lines of force able to pass; (4) and that as electric currents are generated by the alteration of the number of lines of force passing through coils, then (5) the forcible separation of magnetic surfaces by the fraction of an inch will generate electric currents in surrounding coils; and, lastly (6), as this separation is so small, it can be brought about by that strongest of all forces—molecular expansion and contraction, caused directly by the heat of a furnace acting upon iron bars. The new molecular generator consists, then, in the application of bars of iron, each attached to one part of a magnetic circuit; and these bars, when alternately expanded and contracted in suitable manner, shall forcibly break the magnetic circuit, and, in this way, generate electric currents. The touching of the surfaces causes the lines of force to travel almost entirely through the iron, while the separation of the surfaces, even to the slightest extent, causes the lines of force to strike out through the surrounding coils, and so induce currents in these coils. Direct currents can be obtained by arranging suitable commutators; and liquids can be used in pistons as expansible material if desired. The idea involved is ingenious, and the method of generating direct from molecular expansion is pretty; but whether the system is destined to play any practical part in the abolition of the boiler-engine combination that we all desire, is not at present by any means clear.

Maintaining the Popularity of Gas.—Before the members of the Eastern Counties Gas Managers' Association, Mr. James Lee, of St. Leonards-on-Sea, read a paper upon the above vital subject to gas companies, which hardly needed the apology he made for discussing it. When Murdoch, in 1792, first lighted his office at Redruth with gas, the inventor little thought of the wonderful importance to-day of the trade, says Mr. Lee, and rightly says; but what gas managers seem to forget is that the same progress is growing to-day with the Swan lamp, and far faster than Murdoch's flame grew. Not that the reader of the paper was unwilling to deal with the rivalry of electric light. In spite of their antagonism expressed or understood, the silence upon the subject, which was once deemed all that was necessary, is now changed to the devotion of half the space of both paper and discussion on the "popularity of gas" to the progress of electric lighting. Bath has 40 miles of cable laid; Dublin are about to spend £50,000 on a central station; Lewes Town Council, unless they come to terms with the gas company, are considering the offer of the Gulcher Company to install a plant before Christmas; and Hastings Pavilion has had its 300 gas-jets displaced during the last month—all of which "must give us pause," thinks Mr. Lee. "It has been stated," he says, "again and again that the difference in cost between electricity and gas is so great that we need have no fear. But let every gas manager bestir himself; for we shall, in a very short time, see that, though this rival is but in its infancy, it is fast growing in strength and popularity." So in order to keep up the popularity of gas he proposes to do away with the charges for fixing meters, urges managers to consider the third-class persons and help them with their fittings, and apply the prepayment or penny-in-the-slot principle as in practice used at Ramsgate and is now being introduced in Birmingham. What a change in character we are making in the gas companies. Once the haughtiest and sternest of the stern, they now truckle to the penny-in-the-slotter, and seek by every means to enhance their "popularity." But the electric light is their best friend, Mr. Barratt, of Grantham, said in the discussion, for it spurs gas managers to do their duty. Mr. Arthur Mead, of Chelmsford, thought that the electric light was merely a bogey, and cautioned the members not to get scared. He had had some competition at Chelmsford, but had pointed out to several gas companies who thought they ought to send in lower tenders, that as Messrs. Crompton were supplying light at 2d. per unit while it cost them 7d. or 8d., there was no need to be frightened. Mr. A. Mitchell thought that electric light for streets was simply unjustifiable extravagance, but all the same, he said he thought the gas companies ought to be the ones to spend more money, to give more light. Perhaps the most satisfactory thing about it all is that the President, and most of the other gas managers, conclude that the spread of electricity is no cause for alarm, as wherever electricity had been adopted additional demand was created for light, and it was found that the gas supply did not suffer in the least.

THE EDINBURGH EXHIBITION.—XVII.

Messrs. Laurence, Scott, and Co., Limited, of Norwich, show on the stand of their agents for Scotland (Messrs. Norman and Son, Limited, Glasgow), among other things, one of their "D 7" dynamos, being driven by a long-stroke engine by Messrs. Ransomes, Sims, and Jefferies, of Ipswich.

Fig. 1.

This dynamo we illustrate, Fig. 1. The magnets are of the "Kapp" type, made of specially soft cast iron. As will be seen by the illustration, the machine has three very long bearings. The magnets are very massive, and the whole thing makes a perfectly rigid job. The armature is built up on the system which Messrs. Laurence, Scott, and Co., Limited, have used successfully for several years; it is a drum armature, and the plates are stamped with hexagon holes placed together, with the insulating material between them on a temporary hexagon mandril, which, being removed, the hexagon spindle is driven into them very tightly with strips of vulcanised fibre to insulate the plates from the spindle. A section of this type of armature is shown with magnets of the Manchester type, from which it will be seen that the conductor is wound in deep and narrow slots milled into the plate, Fig. 2.

Fig. 2.

The output of the machine is 110 volts, 140 amperes, at 1,160 revolutions per minute. There are 70 sections in the commutator, and 70 turns of conductor on the armature, so that there is only one turn of conductor per section. The armature core is nearly square in longitudinal section, being 7¼in. in diameter, and 7½in. long. The conductor on the armature consists of two parallels of ·12in. round wire braided, the resistance of the armature when hot being ·024 ohm. The shunt winding consists of 147lb. No. 17 wire, and the series of 73lb. No. 6 wire, in four parallels; there being 8,560 ampere-turns in the shunt, and 5,520 in the series—total number of ampere-turns 14,080. The watts lost in the field magnets are 408. The total electrical efficiency of the machine 94·6 per cent. The total weight of conductor on the armature, including commutator connections, is only 21lb., being 733 watts per pound of copper.

We also illustrate this firms ship-lighting plant, Fig. 3. The armature of the dynamo is of the same type as that of the belt-driven one described above, and a section of it and of the magnets is shown below. This construction of armature is specially applicable to these slow-speed direct-driven machines, in which the strains between the shaft and the armature conductor are so much greater and more trying than in an ordinary belt-driven machine. The output of the dynamo is 60 volts 75 amperes at the slow speed of 260 revolutions per minute.

Messrs. Laurence, Scott, and Co., always test these ship-lighters before leaving their works for six hours at "load and a half," and for 12 hours at full load.

The engine is by Messrs. Sabberton Bros., of Norwich. The crank is of forged steel, slotted and fitted with balance weights; the connecting rod, also of forged steel, is six cranks long. All the bearings and wearing surfaces are very large and fitted with suitable lubricating arrangements to enable it to run continuously at a high speed. The cylinders are 6in. diameter and 6in. stroke, and the engine will run well up to 400 revolutions per minute.

Fig. 3.

ON THE FORM OF SUBMARINE CABLES FOR LONG DISTANCE TELEPHONY.*

BY W. H. PREECE, F.R.S.

At the Newcastle meeting last year I gave the reasons and experiments which led to the conclusion that telephoning between London and Paris was practical. New and distinct overground lines of four copper wires are now being erected by the respective governments from each capital to the coast, and a new cable, the joint property of the two governments, will be laid during this month, between the Kent coast and San Galle, to connect these two lines. There will thus be two metallic circuits between the two capitals. The K R, that is the product of the capacity, K, and the resistance, R, of each circuit, upon which the clearness of articulation depends, will be 5,300, indicating that speech should be excellent.

A somewhat similar circuit has been established, since October last, between Buenos Ayres and Monte Video, under my advice. The cables across the La Plata are each 28 miles long, for there are two separate single-wire cables, and the total distance between the two cities is 180 miles. Subscribers, who have metallic circuits in each city, have no difficulty whatever in speaking to each other from their respective offices, although the K R is as high as 10,400.

The cable across the Channel will be a four-wire cable, and the specification for its construction has been based on the following mathematical development by Mr. H. R. Kempe.

Let there be a looped telephonic line between A and B, with a cable C, at an intermediate point on the route.

The working capacity of the whole line is dependent upon the product of the total resistance, R, and the total capacity,

* Paper read before the British Association.

We have then for 400lb. wire

$$a = 3{,}124{,}884$$
$$b = 4{\cdot}356481$$
$$r = 1{,}125$$
$$k = 1{\cdot}95$$

If we take K R = 7,500, which is the highest value that can safely be taken, we get

$$\text{B} = \frac{7{,}500 - 1{\cdot}95 \times 1{,}125}{3{,}124{,}884 \times 4{\cdot}356481} = {\cdot}000389779$$

$$2\,\text{B}\,\text{C} = \frac{2 \times {\cdot}000389779 \times 1{\cdot}95}{4{\cdot}356481} = {\cdot}000348937$$

$$\sqrt{2}\,\text{B} = {\cdot}000551231$$

$$\text{A}\,\text{C} = \frac{1{\cdot}95 \times 1{,}125}{3{,}124{,}884 \times 4{\cdot}356481} = {\cdot}0001611454$$

From this we get

$$\sqrt{\text{B} + \text{A}\,\text{C}} = {\cdot}02347177,$$

$$\sqrt{\text{B} + \text{A}\,\text{C} + 2\,\text{B}\,\text{C}} = {\cdot}0299977,$$

$$\sqrt{2}\,\text{B} = {\cdot}000551231,$$

so that $x = \dfrac{{\cdot}02347177 + {\cdot}0299977}{{\cdot}000551231} = 97{\cdot}00014,$

and extreme diameter of strand $= 97{\cdot}00014 \times \dfrac{100}{95} = 102{\cdot}1054$ mils.

Since $\text{K}\,\text{R} = (k + \kappa)\,(r + \rho)$

we get $\kappa = \dfrac{\text{K}\,\text{R}}{r + \rho} - k$

$$= \frac{7{,}500}{1{,}125 + \dfrac{3{,}124{,}884}{(97{\cdot}00014)^2}} - 1{\cdot}95 = 3{\cdot}197153$$

But $\kappa = \dfrac{1{\cdot}89199468}{\log \dfrac{\text{D}}{x}}$

therefore

$$\log \text{D} = \frac{1{\cdot}89199\ldots}{\kappa} + \log x = \frac{1{\cdot}89199468}{3{\cdot}197153} + 1{\cdot}9867724,$$

$$= 2{\cdot}5785475 = \log \text{ of } 378{\cdot}86,$$
$$= 380 \text{ mils approximately.}$$

If we take

$x = 95$ then $\text{D} = 378{\cdot}94,$
„ $97{\cdot}00014$ „ $378{\cdot}86,$
„ 99 „ $379{\cdot}08,$

which proves the correctness of the calculation for a minimum.

The values of these diameters correspond very closely to a core the weight of whose conductor is 160lb., and the weight of whose guttapercha covering is 300lb., and it has therefore been decided to adopt those dimensions.

Although the calculation has been made on the assumption that the land lines on both sides of the cable are to be of 400lb. wire, the French Government have decided that the wires to be erected by them shall be of 800lb. weight; the result of this will be to reduce the value of K R to 5,300, as stated at the commencement of the paper.

The specification of the cable states that: (1) Each conductor shall be formed of a strand of seven copper wires all of equal diameter, shall weigh 160lb. per nautical mile, and shall at a temperature of 75deg. F. have a resistance not higher than 7·632 ohms or lower than 7·478 ohms per nautical mile.

(2) Each conductor shall be insulated by being covered with three alternate layers of Chatterton's compound and guttapercha, beginning with a layer of the said compound, and no more compound shall be used than may be necessary to secure adhesion between the conductor and the layers of guttapercha. The dielectric on each conductor shall weigh 300lb. per nautical mile, making the total weight of each conductor, when covered with the dielectric, 460lb. per nautical mile.

(3) The inductive capacity of such insulated conductor shall not exceed ·3045 microfarad per nautical mile.

(4) The insulation resistance of each coil of core shall be not less than 500 megohms per nautical mile after such coil shall have been kept in water maintained at a temperature of 75deg. F. for not less than 24 consecutive hours immediately preceding the test, and after electrification during one minute.

The cores (four in number) are to be served with the best net fully tanned yarn, and with a sheathing of 16—280 mil wire, each having a minimum breaking strain of 3,500lb. and a minimum of 10 twists in 6 inches. The section of the cable is shown by the figure.

SOME NEW FORMS OF DYNAMOS.*

BY F. L. O. WADSWORTH.

In view of the recent great activity among electrical inventors, and the great number of new forms recently brought out, I am by no means certain that the machines to which I wish to call attention are new to all readers. They have not, however, to my knowledge been described, and as they seem to possess certain advantages in the way of low speed, high efficiency, and simplicity of mechanical construction which may, perhaps, make them of some practical value, I will give a brief description of two or three machines which I have recently designed.

Fig. 1.—Alternator Armature and Poles.

In this connection I also wish to call attention to a design of a machine the principle of whose operation is identical with that involved in Prof. Thomson's new machine recently described in the *Electrical World*. The design was communicated to me more than a year and a-half ago by Mr. B. G. Lamme, M.E., now with the Westinghouse Company. The theoretical importance of this class of machines is so great that the description of another form, somewhat simpler in mechanical construction than the one already referred to, may not be out of place.

Fig. 1 shows an end view of the machine with part of the revolving portion of the field magnet cut away in order to render the armature coils clearly visible. Fig. 2 is a longitudinal cross-section. The revolving part of the field consists of a single piece of iron, cast or wrought, with radially projecting pole-pieces, *a*, *a*, *a*, between which are fitted blocks of wood, *b b*, to prevent air disturbances and lessen the resistance to rotation.

* From the *Electrical World*, New York.

The armature coils are twice as many in number as the revolving poles, and were, I believe, originally designed to be wound up out of thin copper ribbon instead of wire, because of the greater compactness of the winding, a construction similar to that employed in the armatures of the Mordey, the Ferranti, and the new Brush machines. These coils may be either wound directly in grooves cut across the end of the laminated portion of the field or preferably on separate removable cores, which are afterward clamped in place against the end of the field. The stationary part of the field consists of a casting on which is first wound the exciting coil, and then a casing of sheet iron, against the outer end of which the armature coils are placed.

It will be seen that in this as in Prof. Thomson's machine there is no external magnetic field, no commutator (unless direct currents are desired), and no sliding contacts; and that, as already stated, the principle of its action is exactly the same. It possesses, I think, some mechanical advantages over the former, as there are a less number of parts, not so much fitting, less weight in the revolving parts, and more convenient arrangement of the armature coils, which may be removed or adjusted while the machine is running. For reasons of symmetry I think that it would be desirable to double the thickness of the revolving portion and place another stationary part exactly similar to the one already described at the left, the two parts being bolted to a common bed-plate.

Of the special forms which I shall now proceed to describe the first (in order of design) is a machine of the

Fig. 2.—Alternating Dynamo.

so-called unipolar type, a type to which a large amount of attention has recently been deservedly called, because of the great simplicity both of its electrical and mechanical construction, the steadiness and uniformity of current flow, and the large output per pound of metal. The great difficulty with such machines has been to obtain a voltage high enough for commercial purposes. In order to obtain such a voltage it has been necessary heretofore either to drive one machine at an excessively high rate of speed, or else to couple a number of machines in series. As has been shown by Prof. S. P. Thompson, Hering, and others, no series arrangement of windings is possible in a strictly unipolar machine, and in order to join successive windings in series sliding contacts must be used. This introduces another difficulty in the shape of friction. Brushes have been used with a fair degree of success in machines designed by Siemens (rotating hollow cylinder), Forbes, Poleschko, and others, but if a number of inductors are to be joined in series by means of sliding contacts the multiplication in the number of the brushes becomes objectionable both on mechanical and electrical grounds. Furthermore, if the inductors be in the form of discs rotating in a uniform magnetic field, the use of brushes bearing at isolated points of the circumference will deflect the stream-lines and cause cross or eddy currents in the disc unless the latter is cut radially. If, however, the field is uniform and symmetrical with the axis of rotation—viz., if the outer and inner boundaries of the field are concentric circles having that axis as a centre, and the centre and circumference of the disc be connected to conductors of sufficient capacity—it may be proved that the rotation of the disc in such a field produces a flow whose equipotential lines are concentric circles and whose stream-lines are therefore radii. In fact, these conditions can never be satisfied, although practically they may be so nearly satisfied that it is unnecessary to slit the disc radially.

Furthermore, the employment of a field like that just described makes it possible to utilise nearly the entire amount of copper in the disc as a conductor of current. The means taken to secure the two necessary conditions just referred to—viz., a uniform and axially symmetrical field, together with a high voltage without excessive speed—are shown in the accompanying figures.

Fig. 3 is a cross-section showing the position of the discs, the exciting coils and the magnetic circuit, which is, as will be seen, perfectly closed with but one air gap, there being no external magnetic field. A A are the two revolving discs which are mounted on and driven by the same shaft, the magnetic field being so arranged that while the current flows from the centre to the circumference in one disc, it

Fig. 3.—Horizontal Disc Dynamo.

flows from circumference to centre in the other. Each disc is built up either of a number of thin copper plates insulated from each other, or of a number of segments each of the full thickness of the disc insulated from each other after the manner of commutator segments. Corresponding parts of the two discs are connected with each other at the centre by a system of concentric circular tubes or bars, also insulated, and contact is made along the entire outer circumference of each part by attaching to it by soldering or welding (electrically) a band or rim, which revolves in a trough filled with mercury, as in Fig. 4, which shows in cross-section the group of concentric circular troughs. The base and the division rings are made of rubber, or some other insulating material, and a well-amalgamated copper band, with the upper edge turned down, is placed in each trough, to serve the double purpose of conducting away the current and preventing the overflow of the mercury while the disc is in motion. By this method a very considerable part of the friction caused by a sliding contact is avoided, and the electrical resistance, which is very considerable in the case of brush contact, may be made most negligible. The separate parts of each disc are connected in series with each other with the least possible amount of dead wire by connecting successive troughs, as shown in Fig. 4, the two line terminals being *a* and *b*.

The largest output will be secured when the separate

parts of the two discs are in the form of sectors of solid copper as shown in a top view of one of the discs, Fig. 3*a*. Diametrically opposite segments make connection with the same mercury trough for reasons of symmetry. To find the number of sectors required, consider a case in which the external diameter of the field is 24in., the internal diameter 8in. The area of the pole-pieces will then be about 395 square inches. Assume an air gap whose mean

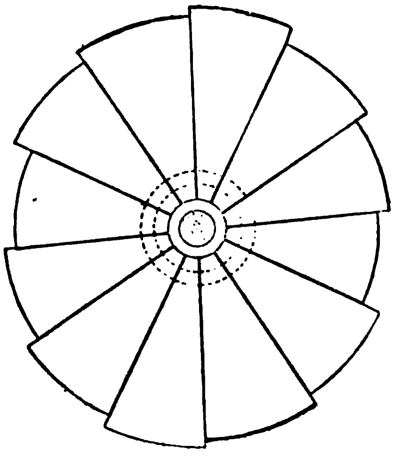


FIG. 3*a*.—Detail of Disc Armature.

width is one-fourth of an inch. With such a width, and with wrought-iron poles, a density of 90,000 lines per square inch can be obtained. The number of lines of force cut each revolution will then be about 35,500,000, and the E.M.F. induced in a conductor cutting this field at a speed of 1,500 revolutions would be nearly 8·9 volts. Twelve sectors in series (six in each disc) would give, therefore, an E.M.F. of 107 volts.

To find the current which could be carried we have, allowing ·09 of an inch (not quite $\frac{3}{32}$ of an inch) for clearance, for the mean cross-sectional area of each one of the copper sectors about ·628 square inches, which by the ordinary rule (520 mils per ampere) would carry 1,200 amperes. The two opposite sectors in parallel would therefore carry 2,400 amperes, and the total output of the machine would be 256,000 watts. Further calculation shows that with a density of 80,000 in the magnet cores the total weight of the iron in the field circuit would be less than 10,500lb. The weight of copper in the field would be 680lb. to 690lb., and the weight of copper in the discs and connections would be 200lb. to 210lb. Allowing 600lb. to 700lb. for shaft, pulley, gears, insulation, etc., the total weight would be less than 12,000lb., and the output would therefore be 21·3 watts per pound of weight, and 284 watts per pound of copper used.*

The design to which I next wish to call attention is that of a machine in which the armature is of the ring type. The field is in this respect novel, in that both internal and external poles, placed opposite to one another, are used, the opposing poles being of the same polarity. In the form of machine due to Mariotti, recently described in the *Electrical World*, both internal and external poles were used, but they were arranged alternately. This latter arrangement, while it possesses some marked advantages, as there pointed out, is open to the objection that one-half of the wire on the armature is dead.

In the present proposed arrangement of opposite poles of the same polarity the wire, both on the interior and exterior of the ring, is employed in generating useful E.M.F., so that a ring with a given number of windings and running at a given speed will generate double the E.M.F. that would be generated in case either external or internal poles alone were used, provided the section of the armature core be increased sufficiently to carry the additional lines of force which will pass through it in the former case.

(To be continued.)

* Since the above was written I have been at work upon a unipolar machine, in which no sliding contacts are used, and all inductor wires are stationary, the details of which I hope to have ready soon.

THE EFFECT OF DIRECT AND ALTERNATING PRESSURES ON THE HUMAN BODY.*

BY J. SWINBURNE.

As there seems to be some doubt as to the relative effects of alternating and direct currents, a bridge which measured the resistance of the patient under various pressures was made up. Fuller readings, which agreed with the first as nearly as such very uncertain readings can be expected to agree, were afterwards taken by putting on different pressures and measuring the current, the resistances being calculated. The alternating currents were measured with a non-inductive wattmeter arranged as an ammeter, the pressure being taken with a hot-wire voltmeter. The tests were taken from hand to hand, the hands being dry or wet with dilute acid in the case of direct currents, and dry in the case of alternating. It seemed to make little difference in the case of alternating currents whether the hands were wet or dry. There was no need to measure the resistance from hand to foot, as that obviously would depend on the boots worn.

HUMAN RESISTANCES: HAND TO HAND.

Current.	Name.	Hands.	Volts.	Resistance.
Alternate	A	Dry	18	950
Continuous	,,	Dry	50	8,000
Continuous	,,	H_2SO_4	50	8,010
Alternate	B	Dry	10	1,330
Alternate	,,	Dry	18	1,110
Continuous	,,	Dry	50	6,660
Continuous	,,	H_2SO_4	50	1,930
Alternate	C	Dry	18	620
Continuous	,,	Dry	50	5,400
Continuous	,,	H_2SO_4	50	1,980
Alternate	D	Dry	18	1,090
Continuous	,,	Dry	50	10,000
Continuous	,,	H_2SO_4	50	16,000
Continuous	E	Dry	50	6,700
Continuous	,,	H_2SO_4	50	1,100
Alternate	,,	Dry	18	1,300
Alternate	F	Dry	18	750
Continuous	,,	Dry	50	3,320
Continuous	,,	H_2SO_4	50	1,710
Alternate	,,	Dry	54	670

In the above table the direct pressure is always 50 volts. Any of those tested could have taken more than this; but even with 50 volts the discomfort is extreme if the contact is made and broken. The maximum current taken was ·04 ampere by E, whose resistance is low. He could have taken more if available. All the resistances are much lower than those obtained by the usual method of measuring with a bridge and one or two cells. Probably polarisation then interferes.

When the direct current from 50 volts is concentrated in one finger it feels hot, though especially as the current is reduced, there can be no appreciable heat generated.

The most curious thing is the very low effective resistance to alternating currents. The alternating pressure could be regulated by steps of 4·5 volts. Out of the five subjects tested not one, except F, could stand more than 18 volts alternating, the maximum effective current taken being ·03 ampere. F seems abnormal. He took 54 volts and nearly a tenth of an ampere. D, who has the highest resistance, was the only lady tested. Though, with the exception of F, none of us could take more than 18 volts, alternating with a good contact, I have several times touched 600-volt alternating terminals lightly. They were given by a Siemens machine used for "flashing" lamps. Before I took charge of the factory containing it I am told several of the girls had shocks from the same machine. Spring switches which demanded both hands to give any current, obviated danger to them afterwards. I have also had a very severe shock from a 100-volt Ferranti. Though 18 volts was as much as we could take, there was no difficulty in letting go.

These results bear out those of Messrs. Lawrence and Harries† as to the relative resistance to alternating and direct currents, but the figures are entirely different. They never found anyone take over 10 milliamperes, while F took 90 milliamperes alternating, and E, a workman, took 44 milliamperes direct, and could have taken far more if available.

Electric Gas Indicator.—M. Eduard Stern, of Cologne, has devised an apparatus for indicating the presence of explosive gas, which does not, however, appear to have by any means the same facility and accuracy of observation as that invented in this country by Mr. Niblett, and would seem, moreover, to be distinctly dangerous. M. Stern's indicator consists of a vessel of porous earthenware, containing in its interior thin metallic membranes, which expand when the gases penetrate the porous sides and make contact for an electric current, and so signalise their presence. By regulating the points the inventor states that any mixture from 1 per cent. up to 20 per cent. could be indicated. This seems extremely problematical, to say nothing of the apparent danger of electric sparks in an explosive mixture at the points of contact.

* Paper read before the British Association.

† *Journal* Institute Electrical Engineering, xix., No. 86.

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Specimen copies of the paper will be sent on request.

THE ACCIDENT AT FLORENCE.

The fatal accident through the electric tramcars at Florence comes with almost disastrous effect at this juncture. Full details have not yet been received, nor will positive proof to the contrary dissipate the fears that many people have with regard to the dangers arising from the increasing use of electricity. It is extremely unfortunate that so many preventable accidents should be permitted to occur. We have at our command the most wonderful agent ever discovered by humanity. Its utility seems endless, and its safety without doubt, yet accidents connected therewith are of frequent occurrence, giving a handle which its enemies are not slow to use. The accident may really have nothing to do with the electrical part of the apparatus, but in the minds of those who hear or read it cannot be separated therefrom. From the meagre details of the Florence accident we have reason to suspect that electricity has no more to do with it than would steam, if a driver was fool enough to turn on full steam with a traction engine at the summit of a steep hill, and had no brakes. Damage to life or property arising from such an action should not be charged against steam, but rather against the management that permitted an incompetent man to control the apparatus. The energy of steam, or of water, or of electricity is to be applied with a certain amount of caution, and if not so applied will certainly lead to accidents. Turn on full current and let her rip, is not a desirable action in tramway work. A runaway car, causing a fatal accident, is possible with horse, steam, cable, or electric traction. It is not unique to electric work. Supporters of electric traction are in this unfortunate position. The system is somewhat new—hence writers to the papers are always anxious to record every item of news concerning it, and the general reader accepts the statement without demur. If unfavourable, it has to be fought down, for it is always treasured as an argument against its use. Years were needed to convince the major part of the public that travelling by steam was safer than travelling by coach, and electrical engineers know there is no reason why travelling by electricity should not be even safer than travelling by steam. The loss of prestige arising from such untoward accidents as that at Florence can only be counteracted by full and accurate information upon the subject. It should be the duty of those who control the system adopted at Florence to make a thorough investigation of the matter, ascertain the facts, and publish a full and complete report. Then it will probably be seen that the accident has been caused by wilful neglect of elementary principles of mechanical engineering. We have again and again contended that the electrical engineer must first be a mechanical engineer, and superpose upon this knowledge that of electrical

triangle joining the fixed centres, and the third lies parallel, or nearly so, facing oppositely. Four magnets will usually form two lines with directions which lie nearly along two sides of the quadrilateral; but diagonally opposite magnets may pair, leaving the others unattached. Suppose them set at the corners of a rectangle with unequal sides, they may lie in any of the forms, Fig. 1A, if the inequality in distance be not too great. All these configurations are stable, and the condition of least energy, while making the first of them the most probable, does not prevent the occasional formation of the others. In a long line, the same condition leads in general to this formation:

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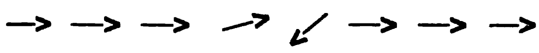
but it is by no means uncommon to find a line broken into two or more sections, thus:



Seven magnets grouped so that the centres of six form a regular hexagon, with one in the middle, have a great variety of possible stable configurations, of which examples are shown in Fig. 2.

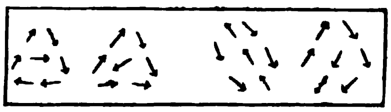


FIG. 2.

Experimental study of the forms which may be assumed by groups, and of the vibrations which may be transmitted through groups is interesting, but to pursue it would be beside my present purpose. In all cases the configuration assumed by a group is such that there is stability for small displacements, but different positions of the group may be stable in different degrees, and if members of the group be turned through a sufficiently great angle they become unstable, and fall into a new position of stability, bringing about a partial reconstruction of the lines that characterise the group. Special interest attaches to square patterns from the fact that iron and nickel (probably cobalt also) crystalise in the cubic system. In a square pattern of many members, we find, in general, lines running parallel with all sides of the square when the group settles without directive force after a disturbance.

Let the group, or collection of groups, be subjected to an external magnetic force, $\mathfrak{h}$, gradually increasing from zero. The first effect is to produce a stable deflection of all members except those which lie exactly along or opposite to the direction of $\mathfrak{h}$. This results in giving a small resultant moment to the group (assuming that there was none to begin with), which increases at a uniform or very nearly uniform rate as $\mathfrak{h}$ increases. This corresponds to the first stage in the magnetisation of iron or other magnetic metal, *a*, Fig. 3. This initial susceptibility is a small finite quantity, and it is sensibly uniform for very small values of $\mathfrak{h}$.

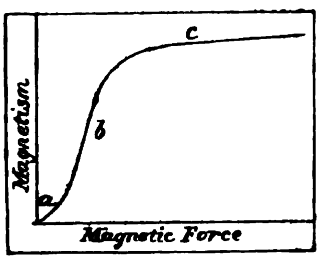


FIG 3.

Suppose that, without going beyond this stage, we remove $\mathfrak{h}$; the molecular magnets, not having been deflected beyond the limit of stability, simply return to their initial places, and there is no residual magnetism. This, again, agrees with the fact that no residual magnetism is produced by very feeble magnetising forces. Up to this point there has been no magnetic hysteresis. But let the value of $\mathfrak{h}$ be increased until any part of the group becomes unstable, and hysteresis immediately comes into play. At the same time, there begins to be a marked augmentation of susceptibility—that is to say, a marked increase in the rate at which resultant moment is acquired. It is not difficult to arrange groups in which the state of instability is reached with one and the same value of $\mathfrak{h}$ throughout the group. But, in general, we shall have different elementary magnets, or different lines of them, reaching instability with different values of $\mathfrak{h}$. The range of $\mathfrak{h}$, however, which suffices to bring about instability throughout the whole, or nearly the whole, of the members in most groups is not large; we therefore find in the action of the model a c-ose analogy to the second stage, *b*, Fig. 3, of the process of magnetisation, in which the magnetism rises more or less suddenly, as well as to the first stage, *a*.

During the second stage, *b*, the magnetic elements fall for the most part into lines which agree more or less exactly with the direction of $\mathfrak{h}$. If, at the end of this stage, we remove $\mathfrak{h}$, we find that a very large proportion of the moment which the group has acquired remains; in other words, there is a great deal of residual magnetism. To take an instance, suppose we have a group lying initially as in Fig. 4, and apply a magnetic force, $\mathfrak{h}$, in the direction sketched, the first stage, *a*, deflects all the molecular magnets slightly, without making any of them become unstable; the second stage, *b*, brings the molecules into the general direction shown in Fig. 5, or rather that is the direction they assume when $\mathfrak{h}$ is removed, and the residual magnetism contributed by the group is then the sum of their moments resolved along $\mathfrak{h}$. When $\mathfrak{h}$ is acting, the components along $\mathfrak{h}$ are slightly greater, for the molecules are then (stably) deflected through a small angle towards the line of $\mathfrak{h}$.

Let $\mathfrak{h}$ be further increased—we now have the third stage, *c*, Fig. 3, which consists in the closer approach to saturation that is caused by the molecules being more nearly

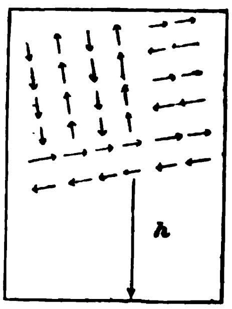


FIG. 4.

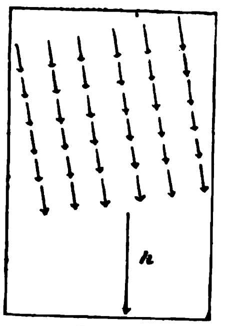


FIG. 5.

pulled into exact line with $\mathfrak{h}$, Fig. 6. Whether there will be instability during the deflection of them from the lines of Fig. 5, will depend on the closeness of the poles, and on the inclination of the lines of Fig. 5 to the direction of $\mathfrak{h}$ (see below). In some groups saturation will be complete with a finite value of $\mathfrak{h}$; in others, it will only be closely approximated to. In magnetising any actual specimen of iron, we have, of course, to deal with a multitude of groups, the lines to which lie at very various inclinations to $\mathfrak{h}$. If we remove the force, $\mathfrak{h}$, at a point in stage *c*, we find very little, if any, more residual magnetism than was found at the end of stage *b*. The ratio of residual to induced magnetism is a maximum about the end of stage *b*, and diminishes as stage *c* proceeds. This, again, agrees completely with the observed facts.

(*To be continued.*)

NOTES ON THE VULCANISATION AND DECAY OF INDIARUBBER.*

BY WILLIAM THOMSON, F.R.S.ED., F.C.S.

Under ordinary conditions indiarubber for vulcanising is usually mixed with sulphur and heated to a high temperature, when chemical combination takes place between the sulphur and the rubber, producing a much more valuable compound for ordinary purposes than unvulcanised rubber, the former remaining plastic at very low temperatures and

* Paper read before the British Association.

firm at high temperatures, whilst the latter becomes hard and quite soft respectively at those temperatures.

In making cloth for waterproof garments another method is employed for vulcanising the rubber—viz., by wetting its surface with a mixture of somewhere about five to 10 parts of chloride of sulphur dissolved in 100 parts of bisulphide of carbon, and then heating the fabric gently to evaporate away the excess of these substances; the rubber-covered cloth cannot be heated to a high temperature like the rubber alone, because the heat would be liable to injure the cotton, silk, or wool of the fabric, or destroy or injure the colours.

The bisulphide of carbon softens and penetrates the fine layer of rubber, carrying with it the chloride of sulphur dissolved in it, and it is generally supposed that the chloride of sulphur breaks up, the sulphur combining with the rubber, producing vulcanisation, and the chlorine combining with the hydrogen producing hydrochloric acid, which is liberated. This reaction is clearly not the correct one, and it is probable that the reverse is more in accordance with the facts—viz., that the chlorine of the sulphur chloride combines with the rubber, producing vulcanisation, leaving the sulphur in the free state, or only partially in combination with the rubber, because in rubber vulcanised by the cold process I have found free sulphur to be present.

From a piece of rubber-covered cloth I separated the rubber and submitted it to analysis by mixing it thoroughly in small pieces with pure sodium carbonate and igniting, then dissolving the whole in water and adding to it peroxide of hydrogen previously treated with excess of barium chloride (to separate sulphuric acid or sulphates). The peroxide ensures the conversion of the lower oxides of sulphur into sulphuric acid, whilst the excess of barium chlorides precipitates the sulphuric acid in the solution which is then weighed as barium sulphate.

Another portion of the made up solution was neutralised and the chlorine present titrated. The rubber, previous to ignition as above described, had been well boiled in water and dried to separate any hydrochloric acid which might be present, but only a faint trace of chlorine compound could be thus separated from the rubber.

The total sulphur present in the rubber amounted to 2·60, and the total chlorine to 6·31 per cent.

The yellow-coloured sulphur proto-chloride is best adapted for vulcanising, because it does not act too strongly upon the rubber, whilst the dark-coloured chloride of sulphur, containing as it does a large quantity of the higher chlorides of sulphur, renders the rubber quite hard by vulcanising it too much. The theory generally adopted to explain this is that these higher chlorides break up easily, liberating their sulphur, which thus combines in greater quantity with the rubber, but my experiments and analyses prove that it is chiefly the chlorine and not the sulphur of the chloride of sulphur which produces the vulcanisation.

A rubber substitute, much used at present, is produced by acting on vegetable oils, such as rape, linseed, etc., with a mixture of chloride of sulphur and bisulphide of carbon. The oil becomes converted into a solid substance resembling indiarubber to some extent, but being much more brittle. This body is now used in large quantity for mixing with indiarubber for the purpose of cheapening its production. On analyses of some samples of this material I have invariably found that it contained a much greater proportion of chlorine than of sulphur, and this process, therefore, is a vulcanisation by chlorine rather than by sulphur.

Recently I analysed three samples of rubber substitute, the one termed "special," another "spongy" indiarubber substitute, the third being similar to the first in appearance. The first contained of sulphur 3·4 and of chlorine 7·6 per cent.; the second contained of sulphur 4·56 and of chlorine 8·22, and the third 2·67 of sulphur and 7·90 of chlorine per cent.

These rubber substitutes contain considerable quantities of oily matters soluble in ether, which I have also found to be chlorine and sulphur compounds of the oils. The first yielded 20·0 per cent., the second 14·3, and the third 11·5 per cent. of these thick oily matters soluble in ether. This oily substance from the first sample contained 2·6 per cent. of sulphur and 6·1 per cent. of chlorine, whilst that from the second contained 2·97 and 6·87 per cent. of sulphur and chlorine respectively.

Some rubber manufacturers regard this oily matter as injurious to the rubber, and reject any substitute which contains any considerable proportion of it. I have found, however, by experiment, that this oily compound, instead of acting injuriously on indiarubber, actually acts as a preservative of it; some rubber threads were smeared with this oily extract, some of ordinary (unvulcanised) rape oil, and some left untreated; these were put into an incubator at 150deg. F. for a few days, when it was found that the oil-treated rubber was quite soft and rotten, whilst the other two had remained sound. After a few days more the original rubber thread had become quite rotten, whilst the threads smeared with the oily part of the vulcanised oil remained quite sound.

The first and second samples of rubber substituted were examined for soluble chlorides or hydrochloric acid, by boiling in water, the first gave 0·18 per cent. of chlorine soluble in water, and the second 0·05 per cent.

It has been known for some time that copper salts exert a most injurious influence on indiarubber; copper salts are sometimes used in dyeing cloth, which are afterwards employed for waterproofing with indiarubber, and it seems quite astonishing what a small quantity of copper is required to harden and destroy the rubber; and the destructive effect of copper is further enhanced if the cloth contains oily matters in which the copper can dissolve. As an example, here is a piece of cloth alleged to have damaged the thin coating of indiarubber on it. I found it to contain copper, and with a view of demonstrating this point I took one piece in its original condition. To the end of this I pasted a similar piece of the cloth from which the oily and greasy matters had been removed by ether, and to the end of this again I pasted another piece of the same cloth from which I had removed both oily and greasy matters and copper. These three pieces joined into one were then coated in the usual way with indiarubber, and then hung in an incubator at 150deg. F. In the course of a few days the rubber on the original cloth had become soft, and it then hardened and became rotten and useless. The second piece from which the greasy matters had been removed then became quite hard and rotten, whilst the part from which both greasy matters and copper had been removed has remained in a perfectly elastic and good condition.

Prof. Dewar observed, accidentally, that metallic copper when heated to the temperature of boiling water in contact with the rubber, exerted a destructive effect upon it. With a view of finding whether this was due to the copper *per se*, or to its power of conducting heat more rapidly to the rubber, I laid a sheet of rubber on a plate of glass and on it placed four clean discs, one of copper, one of platinum, one of zinc, and one of silver; after a few days in an incubator at 150deg. F., the rubber under the copper had become quite hard, that under the platinum had become slightly affected and hardened at different parts, whilst the rubber under the silver and under the zinc were quite sound and elastic.

This would infer that the pure metallic copper had exerted a great oxidising effect on the rubber, the platinum had exerted a slight effect, while the zinc and silver respectively had had no injurious influence on it. A still more curious result was this, that the rubber thus hardened by the copper contained no appreciable trace of copper, the copper therefore presumably sets up the oxidising action in the rubber without itself permeating it. I have pleasure in acknowledging the assistance rendered to me in this experiment by my assistant, Mr. Frederick Lewis.

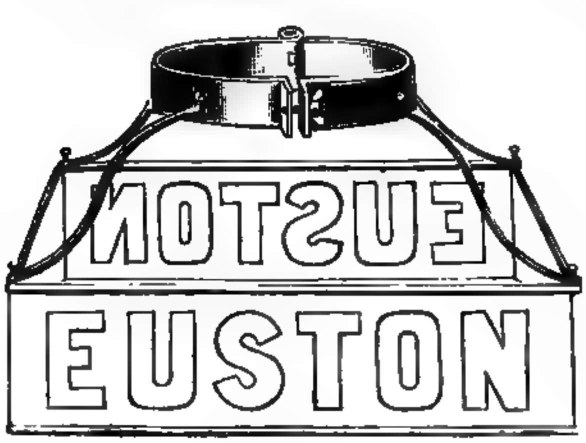
Utilising Water Power.—A dam, to develop 20,000 indicated horse-power, is to be constructed across the Missouri river, near Helena, Montana. It will be a timber crib structure 47ft. high and 800ft. long, forming an impounding reservoir with an area of 429 miles. The water will be taken from above the dam to the turbines by a tunnel 15ft. by 17ft. cross section driven through a rock promontory. The total cost is estimated at 100,000dols. The power developed is to be transmitted electrically to Helena, 13 miles distant.

ELECTRIC STREET SIGNS.

With the spread of arc lighting in shops and public places it will not be long before the users of the lamps take means of utilising the greater brilliance of the light for advertising purposes otherwise than by the simple brilliancy itself. One of the most obvious and easy methods of doing this is well shown by the accompanying illustrations, which represent the street signs for arc lamps (Wade's patent) introduced

Street Signs on Arc Lamps.

by the Street Lamp Company, of Broad-street, Birmingham, a company devoting themselves to public lighting apparatus and fixtures. A light brass framework is fitted with opaque glass bearing the signs desired—the name of the lighting company, the shop using it, the railway station or theatre, as desired. These tablets are visible by day as



Station Signs on Arc Lamps.

well as by night, and are likely to come into general use as the obstruction to light is inappreciable, and no more prominent means of public notice can be well devised. These signs are in use by the Brush Electric Company at the Edinburgh Exhibition, and are very noticeable, and at the same time neat and inoffensive. They are detachable, and, of course, can be made of various shapes and patterns. We understand that a similar arrangement for outside Sunbeam lamps for hotels and business houses will also shortly be brought out by the same makers.

MEMORIAL TABLET TO GAULARD.

The following is the translation of the inscription on the tablet erected to M. Lucien Gaulard at Lanzo, and unveiled on the 3rd of this month:

Here in the year 1884
Lucien Gaulard, of Paris,
first overcame
with alternate currents
the difficulty of transmission to long distances
of electrical energy
Under the auspices
of the Italian Electrical Society of Milan
with the assent
of the Turin-Lanzo Railway Company
his admirers.

The tablet is carved in low relief from the chisel of Sig. Cesar Biscarra, of Turin. The figure of Gaulard is encircled with oak and laurel. Above is the transformer to which the inventor owes his fame. A spirit, seated amongst ruins, which symbolise the troubled career of the unfortunate electrician, is blowing a trumpet above the figure. The erection of this memorial is due almost entirely to the initiative of Sig. Alex. Volta, president of the Italian Society of Electricity.

CHELSEA ELECTRIC LIGHTING.

[The following is the report of the surveyor, Mr. T. W. E. Higgins, A.M.I.C.E., to the Chelsea Vestry. The report is dated May 6, 1890.]

As desired by the Electric Lighting Committee, I propose to deal with this subject rather more fully than I have with other matters.

At the commencement of the year 1889-90 the three electric light companies whose operations extended to Chelsea were:

(1) The Chelsea Electricity Supply Company.
(2) The London Electric Supply Corporation.
(3) The Cadogan Electric Light Company.

Their systems of supply may be described as follows, viz.:

(1) The Chelsea Electricity Supply Co.

The system adopted by this company is that of supply by means of direct continuous currents. There is a generating and accumulating station in Draycott-place, and accumulating stations at Clabon-mews and Pavilion-road. The batteries at the accumulator stations are charged from the generating station in Draycott-place by charging mains at a pressure of 3,000 volts. From these accumulating stations the distributing mains carry the current direct to the consumers' premises at a pressure of 100 volts.

(2) The London Electric Supply Corporation.

The system adopted by this company is a supply by means of high-pressure alternating currents and transformers.

The company have a generating station at Deptford, from whence trunk mains carry currents at a pressure of 10,000 volts to transforming stations. From these stations the currents will be taken by means of distributing mains at a pressure of 2,400 volts to the consumers' premises, where it will then be transformed into 100 or 50 volts, as desired, by means of a transformer on the premises.

This company's system is not yet completed, and, at present, I believe the electricity supplied in Chelsea is generated at their Grosvenor station.

(3) The Cadogan Electric Light Company.

The system of supply adopted by this company is that of direct continuous high-tension currents. The generating station is at Manor-street, and from this station the distributing mains take a current of about 2,000 volts pressure to the consumers' premises, where each consumer has his own secondary battery, which is charged by the distributing main, and from which his house is supplied.

At the commencement of the year the electric light

companies stood in the following positions with reference to the Vestry.

(1) The Chelsea Electricity Supply Company, under the terms of the Electric Lighting Order Confirmation Act, 1886, were proceeding to lay down distributing mains through the streets mentioned in Schedule A of that Act, and also in the streets of certain additional areas which had been added with the consent of the Vestry.

The area in which they had thus been authorised to lay their mains may roughly be described as the Chelsea portion of the Hans Town Ward (except the portion north of Hans-road and Cadogan-place North) with the addition of the Leete-street and Sloane-gardens estates.

(2) The London Electric Supply Corporation had received the sanction of the Vestry to their application to lay down an underground cable along Pavilion-road, and were proceeding with that work, although the Vestry had resolved to oppose their application for a provisional order so that they might get certain modifications made therein.

(3) The Cadogan Electric Light Company were supplying electricity to various houses in the parish by means of overhead cables, and had also obtained the sanction of the Vestry to lay an underground cable from their works along the embankment to within a short distance of Tite-street.

This company had not obtained a provisional order nor had expressed any intention of applying for one.

The first step taken by the Vestry during the year 1889-90 was to withdraw their opposition to the London Electric Supply Corporation's provisional order. After a somewhat lengthy enquiry by Major Marindin on behalf of the Board of Trade, the London Company were granted their order, which was subsequently confirmed by the Electric Lighting Orders Confirmation (No. 2) Act, 1889. By this order this company are bound to lay distributing mains within two years in King's-road, east of Church-street, Church-street, Elm-park-gardens, Elm-park-road, and Chelsea Embankment from Oakley-street to Tite-street.

Since the granting of their order, however, the London Electric Supply Corporation have not carried out any works in Chelsea, with the exception of carrying a ventilating pipe from their main in Pavilion-road into the area of No. 22.

Their main is laid just within the parish boundary at the north end of Sloane-street, through the north side of North-street as far as Pavilion-road, and throughout Pavilion-road.

At the end of the year this company were only supplying light to one house in Hans-place.

In May the Chelsea Electricity Supply Company made application to the Vestry to be allowed to lay mains to the boundary of the parish in order to supply a portion of Kensington parish. After the subject had been considered by the Vestry, and an agreement had been entered into by the Chelsea Electricity Supply Company, their application was granted.

The same company added to their area of supply the portion of the parish north of Hans-road and Cadogan-place.

They also made application to the Board of Trade and the Vestry to be released from their obligations to lay mains in Walton-street, D'Oyley-street, Little Cadogan-place, Ellis-street, and Cadogan-street, as they found that there was no demand for electricity in these streets.

As this application was received during the vacation, I communicated with the chairman of the Electric Lighting Committee, and informed the Board of Trade that if it was clearly understood that the suspension of the company's obligations would only continue until a demand for electricity arose in these streets no objection would be offered to such conditional suspension.

During the summer the Board of Trade issued a copy of regulations for the safe and sufficient supply of electrical energy. The draft of these regulations having first been submitted to the Vestry was amended in accordance with their wishes. A copy of these regulations was subsequently served upon the Chelsea Electricity Supply Company, and in accordance with their provisions the company have fixed a Cardew's voltmeter, the readings of which are taken at intervals of 15 minutes between sunset and midnight, and intervals of one hour between 6 a.m. and sunset.

Only one case of the absence of statutory pressure in electric mains has been brought to the notice of the Vestry. In this case Mr. R. Chamberlain, M.P., of Cadogan-square, fixed a meter in his own house, and found that on certain days the pressure had been below the limits permitted by the Board of Trade. This deficiency in pressure was probably owing to the fact that the electric light company were at that time using temporarily a charging station at some distance from Cadogan-square.

The Vestry left the matter in the hands of the Board of Trade, and no further complaint has since been received.

The Chelsea Electricity Supply Company's mains are now laid in Pavilion-road, Sloane-street, Hans-place, Lennox-gardens, Leete-street, Sloane-gardens, Cadogan-place, and the various streets enumerated in their Schedule A, and they are now supplying electricity as follows:

Name of street.	No. of houses supplied.
Herbert-crescent	5
Hans-road	1
Hans-place	8
Lennox-gardens	9
Cadogan square	23
Pont-street	11
Sloane-street	13
Cadogan-place	14
Lower Sloane-street	6
Sloane-gardens	14
Cadogan-gardens	3
Cadogan-terrace	6
	113 houses

In August the Board of Trade served a copy of their regulations as to overhead wires upon the Cadogan Electric Light Company. These regulations were submitted to the Vestry, but it is not part of their duty to see that they are properly adhered to.

The Cadogan Co. made no application to the Vestry of any importance during the year, 1889-90. They are at present supplying about 25 houses, and the total number of lamps in them is about 3,000.

There are therefore in Chelsea actually using the electric light about 139 houses, supplied as follows—viz.:

Chelsea Electricity Supply Co.	113 houses.
Cadogan Electric Light Co.	25 „
London Electric Supply Corporation	1 „
	139

It should be borne in mind that the desire for electric light in Chelsea, is not, as in most parishes, an outcome of the electric lighting mania of 1882, but dates from some four years prior to that period, and that what at first sight looks like slow progress, is really the natural growth of an important industry which in each stage of its advancement bears marks of the careful attention bestowed upon it by the Chelsea Vestry.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

LECTURE I.—HISTORICAL SKETCH.

(*Continued from page 245.*)

In 1840, after Sturgeon had removed to Manchester, where he assumed the management of the "Victoria Gallery of Practical Science," he continued his work, and in the seventh memoir in his series of researches he wrote as follows:

"The electromagnet belonging to this institution is made of a cylindrical bar of soft iron bent into the form of a horseshoe magnet, having the two branches parallel to each other and at the distance of 4·5in. The diameter of the iron is 2·75in.; it is 18in. long when bent. It is surrounded by 14 coils of copper wire, seven on each branch. The wire which constitutes the coils is 1-12th of an inch diameter, and in each coil there are about 70ft. of wire. They are united in the usual way with branch wires, for the purpose of conducting the currents from the battery. The magnet was made by Mr. Nesbit. . . . The greatest weight sustained by the magnet in these experiments is 12¾cwt., or 1,386lb., which was accomplished by 16 pairs of plates, in four groups of four

* Cantor Lecture, delivered before the Society of Art

pairs in series each. The lifting power by 19 pairs in series was considerably less than by 10 pairs in series; and but very little greater than that given by one cell or one pair only. This is somewhat remarkable, and shows how easily we may be led to waste the magnetic powers of batteries by an injudicious arrangement of its elements."

At the date of Sturgeon's work the laws governing the flow of electric currents in wires were still obscure. Ohm's epoch-making enunciation of the law of the electric circuit appeared in "Poggendorff's Annalen," in the very year of Sturgeon's discovery, 1825, though his complete book appeared only in 1827, and his work, translated by Dr. Francis into English, only appeared (in Taylor's "Scientific Memoirs," vol. ii.) in 1841. Without the guidance of Ohm's law it was not strange that even the most able experimenters should not understand the relations between battery and circuit which would give them the best effects. These had to be found by the painful method of trial and failure. Pre-eminent amongst those who tried was Prof. Joseph Henry, then of the Albany Institute, in New York, later of Princeton, New Jersey, who succeeded in effecting an important improvement. In 1828, led on by a study of the "multiplier" (or galvanometer), he proposed to apply to electromagnetic apparatus the device of winding them with a spiral coil of wire "closely turned on itself," the wire being of copper from 1-40th to 1-25th of an inch in diameter, covered with silk. In 1831 he thus describes the results of his experiments:

"A round piece of iron, about $\frac{1}{4}$ of an inch in diameter, was bent into the usual form of a horseshoe, and instead of loosely coiling around it a few feet of wire, as is usually described, it was tightly wound with 35ft. of wire covered with silk, so as to form about 400 turns; a pair of small galvanic plates, which could be dipped into a tumbler of diluted acid, was soldered to the ends of the wire, and the whole mounted on a stand. With these small plates the horseshoe became much more powerfully magnetic than another of the same size, and wound in the same manner, by the application of a battery composed of 28 plates of copper and zinc, each 8in. square. Another convenient form of this apparatus was contrived by winding a straight bar of iron, 9in. long, with 35ft. of wire, and supporting it horizontally on a small cup of copper containing a cylinder of zinc—when this cup, which served the double purpose of a stand and the galvanic element, was filled with dilute acid, the bar became a portable electromagnet. These articles were exhibited to the institute in March, 1829. The idea afterwards occurred to me that a sufficient quantity of galvanism was furnished by the two small plates to develop, by means of the coil, a much greater magnetic power in a larger piece of iron. To test this, a cylindrical bar of iron, $\frac{1}{2}$in. in diameter, and about 10in. long, was bent into the shape of a horseshoe, and wound with 30ft. of wire. With a pair of plates containing only $2\frac{1}{2}$ square inches of zinc, it lifted 15lb. avoirdupois. At the same time, a very material improvement in the formation of the coil suggested itself to me on reading a more detailed account of Prof. Schweigger's galvanometer, and which was also tested with complete success upon the same horseshoe; it consisted in using several strands of wire, each covered with silk, instead of one. Agreeably to this construction, a second wire, of the same length as the first, was wound over it, and the ends soldered to the zinc and copper in such a manner that the galvanic current might circulate in the same direction in both, or, in other words, that the two wires might act as one; the effect by this addition was doubled, as the horseshoe, with the same plates before used, now supported 28lb. With a pair of plates 4in. by 6in., it lifted 39lb., or more than fifty times its own weight.

"These experiments conclusively proved that a great development of magnetism could be effected by a very small galvanic element, and also that the power of the coil was materially increased by multiplying the number of wires without increasing the number of each."

Not content with these results Prof. Henry pushed forward on the line he had thus struck out. He was keenly desirous to ascertain how large a magnetic force he could produce when using only currents of such a degree of smallness as could be transmitted through the comparatively thin copper wires, such as bell-hangers use. During the year 1830 he made great progress in this direction, as the following extracts show:

"In order to determine to what extent the coil could be applied in developing magnetism in soft iron, and also to ascertain, if possible, the most proper length of the wires to be used, a series of experiments was instituted jointly by Dr. Philip Ten Eyck and myself. For this purpose 1,060ft. (a little more than one-fifth of a mile) of copper wire of the kind called bell wire, ·045 of an inch in diameter, were stretched several times across the large room of the Academy.

"*Experiment* 1.—A galvanic current from a single pair of plates of copper and zinc 2in. square was passed through the whole length of the wire, and the effect on a galvanometer noted. From the mean of several observations the deflection of the needle was 15deg.

"*Experiment* 2.—A current from the same plates was passed through half the above length, or 530ft. of wire; the deflection in this instance was 21deg.

"By a reference to a trigonometrical table, it will be seen that the natural tangents of 15deg. and 21deg. are very nearly in the ratio of the square roots of 1 and 2, or of the relative lengths of the wires in these two experiments.

"The length of the wire forming the galvanometer may be neglected, as it was only 8ft. long.

"*Experiment* 3.—The galvanometer was now removed, and the whole length of the wire attached to the ends of the wire of a small soft iron horseshoe $\frac{1}{4}$in. in diameter, and wound with about 8ft. of copper wire with a galvanic current from the plates used in Experiments 1 and 2. The magnetism was scarcely observable in the horseshoe.

"*Experiment* 4.—The small plates were removed, and a battery composed of a piece of zinc plate 4in. by 7in., surrounded with copper, was substituted. When this was attached immediately to the ends of the 8ft. of wire wound round the horseshoe, the weight lifted was $4\frac{1}{2}$lb. When the current was passed through the whole length of wire (1,060ft.) it lifted about half an ounce.

"*Experiment* 5.—The current was passed through half the length of wire (530ft.) with the same battery. It then lifted two ounces.

"*Experiment* 6.—Two wires of the same length as in the last experiment were used, so as to form two strands from the zinc and copper of the battery; in this case the weight lifted was four ounces.

"*Experiment* 7.—The whole length of the wire was attached to a small trough—on Mr. Cruickshanks's plan—containing 25 double plates, and presenting exactly the same extent of zinc surface to the action of the acid as the battery used in the last experiment. The weight lifted in this case was 8oz.; when the intervening wire was removed, and the trough attached directly to the ends of the wire surrounding the horseshoe, it lifted only 7oz.

"It is possible that the different states of the trough, with respect to dryness, may have exerted some influence on this remarkable result; but that the effect of a current from a trough, if not increased, is but slightly diminished in passing through a long wire is certain.

FIG. 5.—Henry's Electromagnet.

This figure, copied from the *Scientific American*, December 11, 1880, represents Henry's electromagnet, still preserved in Princeton College. The other apparatus at the foot, including a current-reverser, and the ribbon coil used in the famous experiments on se[illegible]dary and tertiary currents, were mostly constructed by He[illegible] own hands.

"[illegible]e this as it may, the fact that the magnetic action of a curr[illegible] from a trough is, at least, not sensibly diminished by passing through a long wire is directly applicable to Mr Barlow's project of forming an electromagnetic telegraph, and it is also of material consequence in the construction of the galvanic coil. From these experiments it is evident that in forming the coil we may either use one very long wire or several shorter ones, as the circumstances may require; in the first case, our galvanic combinations must consist of a number of

plates, so as to give 'projectile force'; in the second it must be formed of a single pair.

"In order to test on a large scale the truth of these preliminary results, a bar of soft iron, 2in. square and 20in. long, was bent into the form of a horseshoe, 9½in. high; the sharp edges of the bar were first a little rounded by the hammer, it weighed 21lb.; a piece of iron from the same bar weighing 7lb. was filed perfectly flat on one surface, for an armature or lifter; the extremities of the legs of the horseshoe were also truly ground to the surface of the armature; around this horseshoe 540ft. of copper bell wire were wound in nine coils of 60ft. each; these coils were not continued around the whole length of the bar, but each strand of wire according to the principle before mentioned, occupied about 2in., and was coiled several times backward and forward over itself; the several ends of the wires were left projecting and all numbered, so that the first and last end of each strand might be readily distinguished. In this manner we formed an experimental magnet on a large scale, with which several combinations of wire could be made by merely uniting the different projecting ends. Thus, if the second end of the first wire be soldered to the first end of the second wire, and so on through all the series, the whole will form a continued coil of one long wire.

"By soldering different ends the whole may be formed into a double coil of half the length, or into a triple coil of one-third the length, etc. The horseshoe was suspended in a strong rectangular wooden frame, 3ft. 9in. high and 20in. wide, an iron bar was fixed below the magnet, so as to act as a lever of the second order; the different weights supported were estimated by a sliding weight in the same manner as with a common steelyard (see sketch). In the experiments immediately following (all weights being avoirdupois) a small single battery was used, consisting of two concentric copper cylinders with zinc between them; the whole amount of zinc surface exposed to the acid from both sides of the zinc was 2-5th of a square foot; the battery required only half a pint of dilute acid for its submersion.

"*Experiment* 8.—Each wire of the horseshoe was soldered to the battery in succession, one at a time; the magnetism developed by each was just sufficient to support the weight of the armature, weighing 7lb.

"*Experiment* 9.—Two wires, one on each side of the arch of the horseshoe, were attached; the weight lifted was 145lb.

"*Experiment* 10.—With two wires, one from each extremity of the legs, the weight lifted was 200lb.

"*Experiment* 11.—With three wires, one from each extremity of the legs and one from the middle of the arch, the weight supported was 300lb.

"*Experiment* 12.—With four wires, two from each extremity, the weight lifted was 500lb. and the armature; when the acid was removed from the zinc, the magnet continued to support for a few minutes 130lb.

"*Experiment* 13.—With six wires the weight supported was 570lb.; in all these experiments the wires were soldered to the galvanic element; the convexion in no case was formed with mercury.

"*Experiment* 14.—When all the wires (nine in number) were attached, *the maximum weight lifted was* 650lb., and this astonishing result, it must be remembered, was produced by a battery containing only 2-5ths of a square foot of zinc surface, and requiring only half a pint of dilute acid for its submersion.

"*Experiment* 15.—A small battery, formed with a plate of zinc 12in. long and 6in. wide, and surrounded by copper, was substituted for the galvanic elements used in the last experiment; the weight lifted in this case was 750lb.

"*Experiment* 16.—In order to ascertain the effect of a very small galvanic element on this large quantity of iron, a pair of plates, exactly 1in. square, was attached to all the wires; the weight lifted was 85lb.

"The following experiments were made with wires of different length on the same horseshoe.

"*Experiment* 17.—With six wires, each 30ft. long, attached to the galvanic element, the weight lifted was 375lb.

"*Experiment* 18.—The same wires used in last experiment were united so as to form three coils of 60ft. each; the weight supported was 290lb. This result agrees nearly with that of experiment 11, though the same individual wires were not used; from this it appears that six short wires are more powerful than three of double the length.

"*Experiment* 19.—The wires used in Experiment 10, but united so as to form a single coil of 120ft. of wire, lifted 60lb., while in Experiment 10 the weight lifted was 200lb. This is a confirmation of the result in the last experiment. . . . . . .

"In these experiments a fact was observed which appears somewhat surprising. When the large battery was attached, and the armature touching both poles of the magnet, it was capable of supporting more than 700lb., but when only one pole is in contact it did not support more than 5lb. or 6lb., and in this case we never succeeded in making it lift the armature (weighing 7lb.). This fact may, perhaps, be common to all large magnets, but we have never seen the circumstance noticed of so great a difference between a single pole and both. . . . . .

"A series of experiments was separately instituted by Dr. Ten Eyck, in order to determine the maximum development of magnetism in a small quantity of soft iron.

"Most of the results given in this paper were witnessed by Dr. L. C. Beck, and to this gentleman we are indebted for several suggestions, and particularly that of substituting cotton well waxed for silk thread, which in these investigations became a very considerable item of expense. He also made a number of experiments with iron bonnet-wires, which, being found in commerce already wound, might possibly be substituted in place of copper. The result was that with very short wire the effect was nearly the same as with copper; but in coils of long wire with a small galvanic element it was not found to answer. Dr. Beck also constructed a horseshoe of round iron 1in. in diameter, with four coils, on the plan before described. With one wire it lifted 30lb., with two wires 60lb., with three wires 85lb., and with four wires 112lb. While we were engaged in these investigations, the last number of the *Edinburgh Journal of Science* was received containing Prof. Moll's paper on 'Electro-Magnetism.' Some of his results are in a degree similar to those here described. His object, however, was different, it being only to induce strong magnetism on soft iron with a powerful galvanic battery. The principal object in these experiments was to produce the greatest magnetic force with the smallest quantity of galvanism. The only effect Prof. Moll's paper has had over these investigations has been to hasten their publication. The principle on which they were instituted was known to us nearly two years since, and at that time exhibited to the Albany Institute."

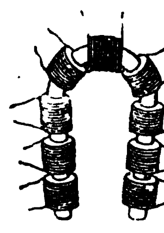


FIG. 6.—Henry's Experimental Electromagnet.

In the next number of *Silliman's Journal* (April, 1831), Prof. Henry gave "an account of a large electromagnet, made for the laboratory of Yale College." The core of the armature weighed 59½lb. It was forged under Henry's own direction, and wound by Dr. Ten Eyck. This magnet, wound with 26 strands of copper bell wire of total length of 728ft., and excited by two cells which exposed nearly 4 7-9 square feet of surface, readily supported on its armature, which weighed 23lb., a load of 2,063lb.

Writing in 1867 of his earlier experiments, Henry speaks thus of his ideas respecting the use of additional coils on the magnet and the increase of battery power:

"To test these principles on a larger scale, the experimental magnet was constructed, which is shown in Fig. 6. In this a number of compound helices was placed on the same bar, their ends left projecting, and so numbered that they could all be united into one long helix, or variously combined in sets of lesser length.

"From a series of experiments with this and other magnets, it was proved that in order to produce the greatest amount of magnetism from a battery of a single cup a number of helices is required; but when a compound battery is used then one long wire must be employed, making many turns around the iron, the length of wire and consequently the number of turns being commensurate with the projectile power of the battery.

(*To be continued.*)

THE BRITISH ASSOCIATION AT LEEDS.

PRESIDENTIAL ADDRESS BY SIR FREDK. AUGUSTUS ABEL, C.B., D.C.L., D.Sc., F.R.S., &c.

(*Continued from page 226.*)

The extensive use which has been made in Germany of smokeless or nearly smokeless powder in one or two special military displays has, however, afforded interesting indications of the actual change which is likely to be wrought in the conditions under which engagements on land will be fought in the future, provided these new explosives thoroughly establish and maintain their position as safe and reliable propelling agents. Although the powder adopted in Germany is not actually smokeless, the almost transparent film of smoke produced by independent rifle-firing is not visible at a distance of about 300 yards; at shorter distances it presents the appearance of a puff from a cigar. The most rapid salvo-firing by a large number of men does not have the effect of obscuring them from distant observers. When machine guns and field artillery are fired with the almost absolutely smokeless powder which we are employing, their position is not readily revealed to distant observers by the momentary vivid flash of flame and slight cloud of dust produced.

There now appears little doubt that in future warfare belligerents on both sides will alike be users of these new powders; the screen-

NOTES.

Personal.—Mr. A. Grundy is retiring from the firm of Messrs. Bailey and Grundy, both of Amberley Works and Cambridge, and is joining the staff of the Gulcher Company from October 1st.

Dutch Electric Tramways.—The electric tramway between the Hague and Scheveningen had to be stopped a few days after the inauguration, as the sparking was such as to make further working at the moment impossible.

Accumulator Cars at Paris.—A small electric railway by accumulators has been running since the beginning of September, between the Chevaux de Marly and the interior of the Exposition at the Palace of Industry.

To Use the Typewriter.—The American Associated Press has given instructions to its telegraph operators to learn the manipulation of the typewriter, as it is found that this instrument materially increases the speed of receiving messages.

The Order Executed.—A Dubbo (New South Wales) newspaper claims to have an extensive and unique circulation. A man advertised in it recently for "an electric battery in good working order," and a few days afterwards his house was struck by lightning.

Cricket Match. — A cricket match between the employés of Woodhouse and Rawson and those of Appleton, Burbey, and Williamson, played at Brentwood on Saturday last, resulted in a slashing victory for the former by 331 runs to 46: Mr. B. T. Thomas's 97 was a large contribution.

Peral Submarine Boat.—A despatch from Madrid announces that the Spanish Naval Board, after examining the official reports and other papers relating to Lieutenant Peral's electric submarine vessel, has decided to advise the Government to construct an improved submarine boat under the direction of the lieutenant.

London Electric Supply.—We are informed by the London Electric Supply Company that their underground mains for distributing current are laid in Victoria-street, Parliament-street, Whitehall, Great George-street, and the neighbourhood, and that the company can connect installations thereto at very short notice.

Water-Gas at Harrogate.—Crowds of people assembled last week in Harrogate to compare the lighting by coal-gas and water-gas, equal number of lights on both systems having been lighted in the streets. The general opinion of the superiority of water-gas, both for beauty of appearance and for illuminating power, seems to have been expressed.

Electric Mining.—The Lechner electrical mining machine, which is manufactured at Pittsburgh, has been put to a severe test at the mines of Capt. Brown, near Boston, and was pronounced an unqualified success. In five minutes the machine cut through a solid piece of coal 3ft. wide and 4ft. 7in. deep. Capt. Brown has been greatly interested in this machine, and now intends to use it in all his mines.

City Lighting.—Before the Court of Common Council, Mr. Altman asked the chairman of the Commissioners of Sewers if he could give any information as to the progress made towards the lighting of the City by electricity. Mr. Deputy Green said that two electrical companies had entered into provisional orders, and those orders had been since granted by Parliament, and it would be the duty of the Commissioners to see that the contracting bodies lost no time.

An Edison Tower.—At the coming electrical exhibition at Minneapolis, the principal feature of the Edison exhibit will be a tower about 70ft. in height and 8ft. in diameter in the middle. This tower, which is of Egyptian design, will bear no less than 7,500 incandescent lamps. From its apex will hang festoons of lamps in various designs, making it the most brilliant thing of the kind in the world.

Personal.—Mr. W. J. Johnston, the proprietor of the *Electrical World*, gave us a look in this week. Mr. Johnston is staying for another week or so in England, and is intending to visit some of the big electrical things on this side, and to take back some ideas as to how things electrical are likely to progress during the next year. Talking of progress, Mr. Johnston seems greatly pleased at the continued success of his own journal.

Smoking Concert.—The first smoking concert of the season by the Electro-Harmonic Society takes place to-night (Friday) at the Banquet-room, St. James's Hall Restaurant, at eight o'clock. The artistes will be Master Steward, Mr. William Nicholl, Mr. Arthur Thompson, Mr. W. G. Forington; violin, Mr. T. E. Gatehouse; solo piano, Mr. Alfred Izard; and humorous selections by Mr. Frederick Upton.

Public Lighting at Cardigan.—A dispute is pending between the Town Council of Cardigan and the gas company as to the supply of gas for public lighting. The Corporation desire to be served by meter, but the gas company refuse to enter into such an arrangement, preferring a fixed charge. Threats have been made to light the town with oil, but in the meantime, as the contract with the company has expired, the town has been in darkness for several nights.

Telephony at Paris.—M. de Selves, Director-General of Posts and Telegraphs, has brought forward a scheme for the complete reorganisation of the telephone system in Paris. He will do away with five out of the 12 central exchanges, and replace these with one large exchange, to be erected in three years near the Hotel des Postes, at a cost of 800,000f., which will serve 6,000 to 8,800 subscribers. He will also extend the telephone service in the suburbs, and connect these with the central bureau.

Canterbury.—A letter was read at the meeting of the Canterbury General Purposes Committee last week from Mr. Sydney Morse, 4, Fenchurch-avenue, on behalf of the Canterbury Electricity Supply Company, asking them to call a statutory meeting to consider the company's application for a provisional order. The town clerk said he proposed replying that as the Council had decided to apply for an order themselves, they were not likely to grant consent to the company. He stated further that the order was in hand.

Magdeburg.—The Town Council of Magdeburg has set aside an area of 2,500 square yards in the north of the town near the River Elbe in order to erect a central station with a capacity of 70 arc lamps and 24,000 incandescent lamps; the plant is to be started with 50 arc lights for the illumination of the streets, and 8,000 incandescent lamps for private consumers. The Grand Theatre, which was to have a special central station for its electric lighting, will now be supplied from the public mains, either direct or by accumulators.

Accumulator Cars in Germany.—At present interesting experiments are made on the line between Hildburghausen and Heldburg with a new method of electric traction. Whilst on the tramways at Bremen Exhibition and Frankfort-on-Maine the overhead wire system is employed, a new accumulator car manufactured by Oerlikon, Zürich, has been tried here. The line was 17 miles long, the radius of the curves being 60 yards and the steepest gradient 1 in 40, and the time required to make the round about six hours—say three miles per hour, including stoppages.

Old Students' Annual Dinner.—The sixth annual dinner of the Old Students' Association will take place at the Holborn Restaurant on the 17th inst. at 7.30 p.m. Tickets, price 4s. 6d. each, may be obtained from the secretary, 14, Garfield-road. The committee trust the members will do their best to attend, as a large gathering is hoped for. It is requested that members will communicate with the secretary before the 10th inst., stating his intention of being present, or his inability to attend. We understand that Mr. W. B. Esson is nominated for president during the ensuing year.

Central Stations at Vienna.—There are at present five central stations in Vienna: (1) Imperial Continental Gas Association Station, for the lighting of the two Court theatres; (2) Berliner Elektricitäts Werke, Messrs. Siemens and Halske, for lighting No. I. town division; (3 and 4) two stations of the Wiener Elektricitäts Gesellschaft, lighting divisions V., VI., and VII.; (5) the station of the International Elektricitäts Gesellschaft (Ganz and Co.) for the whole town. The latter is not yet complete, and will be the largest of the five; alternate currents and transformers will be used.

Westphalia.—There is now a sudden large demand for the electric light in almost all the small industrial towns of Westphalia (Germany). In one of these installations the price of one incandescent lamp of 10 c.p. will be one farthing per hour, if the Town Council grants a concession for 20 years, after which time the plant may be acquired by the town. Among the different tenders are also those of the International Popp Company, which have however, as is understood, very little chance of being accepted. The reason for this sudden demand is to be found in the expiration of the gas company's contracts.

Electric Power Hammer.—Electricity is ousting steam in many directions, so why not also the steam hammer? Mr. Charles J. Van Depoele, whose name is well known in electric motor work in America, has brought out a power hammer for heavy forgings to be driven by electricity. In this, the hammer, or tup, is connected to a reciprocating piston, and this piston is of magnetic material, moving up and down inside a series of magnetic coils or solenoids. By energising these coils, any rate or strength of blow is supposed to be delivered, and the regulation of the blows is made by the means of a simple switch, instead of the steam valve handle.

Financial Criticism.—Any fool can write about what he knows, but it takes a clever man to make people believe what he wishes them to believe without knowing anything about the subject. One of the funniest things, and at the same time possibly one of the most damaging to the public, said about a recent electric company, was as big an instance of mingled acuteness and utter ignorance it has ever been our pleasure to see. "The company are going to use the E.P.S. accumulator," it was said, "and a mighty poor accumulator it is; it weighs some 220lb., and only gives out two volts—not a beggarly 1 per cent!" This is enlightened criticism with a vengeance.

Expansion Generator.—A curious misapprehension of the function of a heat generator of electricity (if it ever comes to actual work) is shown by Mr. W. M. Miner, who, writing in the N.Y. *Electrical Engineer*, suggests that the heating of the expansion bars recently proposed by Edison should be done by the alternate current instead of a furnace! One may ask this gentleman (whose article is given a leading place), how is the alternate current itself to be generated? It would be a pretty specimen of direct generation from heat to generate first an alternate current by engine and boiler, then reduce this to heat, and convert it again to electricity by expansion. Mr. Miner must try again.

The Telegraph in South Africa.—The latest advices from Capetown state that the telegraph line beyond Mafeking, which was commenced by the British South Africa Company last May, has been completed for a distance of 265 miles. It is now within 50 miles of Palatswie, and is expected to reach that place early in October. The work has been effected across a thickly wooded country, as the most direct route was taken, and although Khama and other chiefs encouraged their men to join the working party, the natives were naturally entirely new to the work. Pending the completion of the line, direct communication with Macloutsie is maintained by means of heliograph stations.

Cambridge.—The Electric Lighting Committee of the Cambridge Town Council at the last meeting recommended that certain printed regulations for the supply of electric current by the Corporation to public and private buildings, and the rules and conditions to be observed in the installation of electric conductors and wires in buildings intended to be connected with the Corporation electric supply, be adopted by the Council. Mr. Whitmore, who introduced the report, said it was most important that a code of rules should be adopted. An amendment was moved referring the matter back to the committee, as it was felt that the by-laws should not be put forward before the whole question was decided.

Utilising Water Power in France.—The impetus given to the utilisation of water power by the employment of electricity which is showing itself so prominent at the present moment in America, Italy, Switzerland, and on the Rhine in Germany, seems now, according to information which reaches us this week, to be spreading in the same degree in France. We have signalised various small installations where local water power is used by means of turbines. We now hear that a large project is being seriously put forward—and is in a fair way of actual execution—for the utilisation of the River Rhone at Lyons in the production of 12,000 h.p., of which some 8,000 h.p. is to be transmitted to various mills in the surrounding districts. The cost of this undertaking is estimated at 17,000,000f.

Welding Machines from America.—The *Boston Herald* says that the English Electric Welding Syndicate has just placed an order with the Thomson Electric Welding Company for 16 welding plants for various classes of work from wire to 2in. shafting. Each plant is to be complete in itself, and ready to be placed with different manufacturers in England, who are waiting for them. The works of the welding company at Lynn are crowded to their utmost

with home orders, and it will be at least six months before they can complete this contract. It is the intention of the English company to establish works of its own near London, but until this can be done the American company will assist in every way possible. A contract for the mutual interest and protection of both companies has been executed which will bring the companies into close relationship in the future. The English company is to be brought out probably in November.

Saunderson's Arc Lamp.—*La Lumière Electrique* seems to have a peculiar idea of Saunderson's arc lamp carbons. According to a note, they seem to think that a tube from an ordinary gas bracket is led to the carbon, and the hydrogen of lighting gas is burnt in the arc—" the velocity of the gas being reduced by the asbestos wick." The question is asked, and very rightly, is such a game worth the candle? We should hardly think it would be, indeed! The simple fact in the original description has been evidently overlooked that the hydrocarbon (not hydrogen) gas is generated by the heat of the arc acting on a small tube of " vaseline" or thick mineral grease placed at the bottom of the hollow carbon, and this gas it is that reinforces the arc. There is no question that if, in practice, the arcs give double the light for the simple addition of a daub of vaseline and a strip of asbestos, the game would be very much worth the candle.

Central Station for the Canary Isles.—A plum is offered for the open mouths of electrical engineers. Not often do we find a town of 16,000 inhabitants, as yet without gas, wishing to adopt electricity with overhead distribution. The invidious comparisons and the opposition of gas companies would thus be absent. Such is the case of Santa Cruz, capital of the Canary Isles, the authorities of which are now desirous of receiving tenders for the complete establishment of an electric lighting scheme. It is necessary to add, both in explanation of the absence of gas and as a condition for the consideration of electric distribution, that the nature of the ground at Santa Cruz will not admit of any kind of underground distribution. The site of the town is, as a matter of fact, so very hard that even the number of holes necessary for the erection of posts must be stipulated in the tender, and in the award the number will be diminished by the authorities as far as possible.

Electric Tramway of Budapest.—The electric tramway established at Budapest by Messrs. Siemens and Halske seems to be a complete success both technically and financially. The line is on the underground conduit system and is 7·9 kilometres (just about five miles) in total length, extending along the principal streets of the capital of Hungary, which may now evidently be congratulated upon being the most advanced in city electric traction in Europe. During the month of April the cars carried 337,200 passengers or 42,684 per kilometre per month. Twenty cars are running every day on ordinary days and 24 cars on Sundays and fête days, and the speed of the cars is 11 miles an hour. During the same period of time, the horse tramway of the town, with some 30 miles of route and 329 cars, only carried 33,074 passengers per kilometre, or 9,610 per kilometre less than the electric line. During the month of May the results are even more favourable, as 387,000 passengers were carried.

Dorking is Expectant.—At the last meeting of the Dorking Local Board, in answer to a question by Mr. Clift, the chairman said the cost of public lighting by gas was £800 per annum. Mr. Clift said the reason he asked was that Fareham, in Hants, had just been lighted by electricity and it had been a great success, and everybody was delighted with it, whilst it only cost £500 per annum. The chairman said that the Board had no application before them to light the town by electricity, but Mr. Clift's remarks would be useful when such application was before them. Mr. Clift thought some information might be obtained, because he believed the time would come when they must have the electric light, and the sooner the better, a sentiment that was applauded. The surveyor promised to obtain all the information that was required and lay it before the Board at their next meeting, when the whole question will be gone into.

A Primary Battery Electric Boat.—Mr. Frank A. Perret, electrician of the Elektron Manufacturing Company, of Brooklyn, well known as the inventor of the Perret motors and dynamos, has just completed a new electric boat. At a recent trial, says the *Electrical World*, six cells of ordinary cautery battery of his own construction ran the boat very successfully. The boat is described as being lightly constructed, of canoe shape, and capable of carrying two persons. The motor used is built to run at 10 volts and to take 40 amperes of current. Paddle wheels are used which feather the water automatically, the paddles being in an upright position and never turning over as they would in the old style of paddle wheel. In the test made the power was transmitted from the motor to the paddle wheel shaft by a single round belt, and the battery is said to have furnished enough power to cause the belt to slip. The solution used in the battery is composed of chromic acid and sea water. The test was considered a very successful one.

Coventry.—At the Coventry City Council the Gas Committee recommended, with reference to the notices received from three electricity companies of their intention to apply to the Board of Trade for provisional orders to authorise them to supply electricity for public and private purposes within this city, that the consent of the Council be refused. Mr. Andrews reminded the Council that hitherto the Board of Trade had refused orders for Coventry. In their memorial last year the Council said when they could see that electric lighting could be reasonably adopted, and with any probability of its being supplied at reasonable price and with some profit, they would themselves take it up. So far as could be ascertained only one company was paying a dividend, and at Bradford, where the Corporation worked it themselves, they had lost £1,C00 on the first year's trading. He thought it would be safest for the present to decline to sanction the applications. Mr. Loudon seconded. Although he regarded the electric light as the light of the future, in this country the system seemed to be in a state of chaos. The report was adopted.

St. Pancras Contracts.—At the meeting of the St. Pancras Vestry the Electricity Committee reported that they had accepted the guarantees proposed in regard to the following contracts: 1. Messrs. Kirk and Randall, for buildings. 2. The Babcock and Wilcox Company, for boilers, etc. 3. Messrs. Willans and Robinson, for engines, dynamos, etc. 4 and 5. The Electric Construction Corporation, for switchboards and batteries. 6. Messrs. Mowlem and Co., for trenches. As regards Contract No. 7 for electrical conductors with Messrs. Clark, Muirhead, and Co., the question was left over, in consequence of the gentlemen proposed as sureties being away from home, but this is expected to be settled in a day

or two. The several contracts and bonds have been prepared by the solicitors, and the committee have given directions for the same to be executed as speedily as possible. The seal of the Vestry was then affixed to each of the contracts. The committee have had the site in Stanhope-street cleared, and arrangements are being made for handing over the ground to Messrs. Kirk and Randall, builders, during next week.

Woolwich.—At the meeting of the Woolwich Local Board, Mr. Green moved that the electric lighting of the district should be entrusted to the Board. He said that it was only a question of a few years, when all the great monopolies of gas and water would be acquired by various local authorities in the country. If they granted power to a local company, the monopoly could not be acquired by the Board under 42 years, and then only at the price stipulated by the company. He wished to test the opinion of the Board. Rev. J. W. Horsley said that he had read that it had taken Woolwich 20 years before they came to a decision to use gas, and he hoped that even if the resolution were not passed, people, 20 years hence, would say that at least two men of this generation were in favour of the local authorities dealing with the question. Mr. Vincent suggested that they should wait until the company had been successful. Mr. Grant supported the resolution. Mr. Taylor said that the company would limit their operation to the parts of the town that would pay, but if the Local Board took over the work, they would have to cover the whole district. There voted for the resolution four, against seven. The resolution was therefore lost.

Shocked by a Moving Footplate.—There was a curious scene in Paris the other day (writes a correspondent of the *Daily News*) just outside the Opera House. Traffic was in full swing, when a lady who was crossing the street and had got on to one of the refuges sunk to the ground with a scream. She had put her foot on a large metal plaque, and immediately felt an electric shock. The usual crowd collected, and the usual police arrived. But the cause was clear to all. Quite close to the scene of the accident was a standard of clustered electric lights, and the wire which supplied the current passed close to the metal plate. With great presence of mind the police sent for several electricians, keeping a cordon in the meantime round the plaque. The experts went to work quickly and cautiously. The metal plate itself was raised. It communicated with one of the subterranean passages that lead to the drainage system of the city. Then at last the cause of the accident was discovered. A workman employed in the drains wanted to emerge, and happened to push up the plate at the moment the lady's foot was on it. Hence the earthquake and the shock. Thereupon the crowd dispersed, the electricians went home, the police preserved impenetrable silence, and the lady, who really showed considerable imagination, decided to say as little as possible about the accident.

Starting Cars.—Car starting seems to be a prominent subject in America just at present. The wastefulness of having a 30-h.p. motor which, except at the very start, is only needed to exercise 10 or 12 h.p. seems to be striking the traction engineers, and various devices continue to be promulgated. Mr. Edison comes forward with a patent electric car starter, consisting of a combined double armature—that is, two armatures, both connected with spur gearing to the axle, but capable of having the direction and strength of their fields changed, so that one can act as a motor and the oth— — —namo, or both as motors by the shifting of suitable switches, and so regulates the speed. Mr. John H. Palmer also, the N.Y. *Electrical Engineer* tells us, has brought out in Boston an electric car starter which does away with all trouble and "bids fair to be an unqualified success." The device is not very clearly described, but is said to consist of a variable leverage mechanism obtained by involute wheels, by which an enormously increased leverage is attained on the driving wheels at the moment of starting the car and for some time after. After getting the car fairly set in motion, this mechanism is automatically cut out and the motor continues to drive the car in the ordinary manner, another clutch automatically gearing into the driving shaft an instant before the starting mechanism is cut out. The model exhibited is said to work most accurately, and to exhibit some very pretty mechanical devices. The motor can either be kept running all the time or stopped with every stop of the car as most desired

An American Telpher System.—At the St. Louis Exposition the Unicycle Electric Elevated Railroad Company, of St. Louis, has erected an elevated track for a short distance, on which it is running a small model truck with seating capacity for two persons. In this system the car hangs over the main ordinary rail, having a space running throughout its length along the centre. Two guides project downwards, one on each side, and inclined guide wheels keep the car upright and safe. In constructing the track the main rail is supported by posts and uprights, while bolted to the main rails are side braces on which the guide rails are securely bolted in position. The main wheel of the truck is grooved and rests on the main rail, while smaller grooved wheels, supported from cross bars, fit into the guide rails and practically lock the car to the track. The car bottom and truck frame are movably connected, having friction rollers that play between the car bottom and truck frame, working in a flanged disc. The friction rollers rest on springs which are supported by an under brace, thus allowing the car to turn a short curve with ease and safety. The motor is so constructed that the weight will be equally balanced on the truck frame, while an automatic device is so arranged as to equalise the weight on centre, making it entirely centrifugal and taking off all unnecessary friction. A "C. & C." motor is being used to operate the car. The line is practically an overhead telpher line, but with the cars above the rail in the usual position of elevated railways.

The First Westinghouse Railway.—The first Westinghouse electric road was started at Lansing, Michigan, on August 27, and an account of the line is given in the *Electrical World*. We were under the impression that it was an alternating-motor system that the Westinghouse Company were going to exploit, and still fancy this is so; but nothing is said upon the matter in the description—we are rather led to believe the system (of which much secrecy has evidently been made) is an evolution along the lines of the Thomson-Houston method. The motors, of which there are two of 15 h.p. each, are said to be in general arrangement quite similar to those ordinarily in use. Overhead conductors are used with the usual trolley and yardarm. A special feature of the motor is the ease with which the armature can be removed, the field magnets being hinged so that by withdrawing the fastening bolts they open out. This enables inspection and repairs to be very quite done. There are but two sets of coils on the field magnets, and, in addition to these, starting resistances are used. On starting the car the switch handle is slowly moved over five

notches, cutting out successively the three resistances, and throwing into action successively the two field coils. The gear wheels are of cut steel, with 5in. faces, running in oiltight castings partly filled with oil. The motors are adapted to run up to 20 miles an hour. Six miles of track are laid, and three motor cars, each drawing two or three trailers, are running. At the time of the Lansing Fair a motor car and trailer often carried as many as 250 passengers up a long gradient of 5 per cent. rise, with a curve at the start.

Telephones in Church.—The telephone in the church at Birmingham seems to have been a mingled success—a success in that the solos, choir singing, and sermon were heard widely in many towns; but the holy words seemed not so exclusively confined to the telephone line as they might have been, and calls like "Hello! are you there?" "I want Christ Church, No. 2,006," etc., mingled with the psalms and prayers. The sermon could be clearly heard, and reference was made to "friends at a distance." It was somewhat unfortunate that it should have been a charity sermon, as naturally subscribers could not drop their cash by telephone. It is understood that various protests have been made by perturbed clerics to the manager against the desecration and tendency to absence thus inculcated. The Rev. Canon Wilcox, in his evening sermon, alluded to the fact that not only had he the privilege of addressing such a large gathering as was there gathered, but his words travelled far beyond the limits of that building, and that the sick and the weary, and the weak and the aged and infirm could also hear owing to the wonderful discoveries of science. About 50 local subscribers to the exchange applied to be switched on to the church at each of the three services, but it is probable that many hundreds of people heard portions of the service, inasmuch as each receiver would doubtless have a succession of listeners. Amongst the distant towns connected with the church were London, Manchester, Burton-on-Trent, Derby, Kidderminster, Hanley, and Coventry. Mr. Coleman, the manager of the local exchange, states that many of those in distant towns reported that they had heard the singing and the sermon distinctly.

Telephone from London to Manchester.—Telephonic communication has been opened this week by the National Telephone Company between London and Manchester (a distance of 206 miles by the route adopted), and is being continued further north. The line is not quite ready for use by the general public, but it was placed on Monday, by the courtesy of the officials, at the disposal of the Manchester Field Naturalists' Society, which has been doing yeoman service during the last few months in the way of planting trees in their smoky city, a task which is not without its difficulties. A company of 50 gentlemen, presided over by Mr. Alderman W. H. Bailey (in the absence of the Mayor), and including many members of the Corporation, was present at the Manchester office of the telephone company, and a lively discussion took place on the effect of town fog on animal and vegetable organisms, between Dr. Bailey, of Owens College, and Mr. Oglesby (Manchester), and Colonel Mackenzie, superintendent of Epping Forest, Dr. Charles Roberts, Prof. R. Meldola, F.R.S., and Mr. Philip Hartog, at the London offices, Oxford-court, Cannon-street. It was proposed to take measures to make a systematic examination of the composition of the atmosphere, which, both in London and in Manchester, is becoming more and more unfit to support plant life. The Berliner (a modified Blake) transmitter and the Bell receiver were used, and the voices of the Manchester members were heard quite distinctly in London, and were easily recognisable. After the formal proceedings were over, the London office was connected with the Princess's Theatre, Manchester, and the Manchester office with the Savoy Theatre, London. Owing to the use of "loop" lines—complete metallic circuits—a conversation can now be carried on between London and Manchester without any disturbing noises whatever.

Electric Light for Godalming.—At the meeting of the General Purposes Committee of the Godalming Town Council last week, the report of the Electric Lighting Committee, who recently visited Bath, was considered. The report stated that the members who visited Bath considered the lighting of the streets there with electricity was very satisfactory, and far superior to the street where gas was used, and the lighting for private purposes was equally satisfactory. Great improvements had been effected in the methods of lighting since the last installation in the borough, which made the present lamps and appliances as nearly perfect as they might expect to become. The committee thought, therefore, that the time had arrived when the electric light might be safely adopted, if thought desirable on financial grounds. From definite and amended estimates which the committee had obtained (Messrs. Todman, Day, and Co.'s estimates and letter) they had ascertained that to put down 36 arc lamps and 20 incandescents for the borough public lighting complete, exclusive of the building, but including power and appliances for 300 private lights, would cost £2,050, and with buildings and sundries (say, £450), £2,500. The annual net cost of working the borough lights and private lights might be estimated at £500. If to this were added $\frac{1}{25}$th of the capital sum of £2,500 (making it repayable in 25 years), and 4 per cent. interest, there would be a further annual charge of £200, making a total outlay of £700. This would include at least 300 private lights, which, if taken up, and charged at 30s. per light per annum, would yield £450, leaving a net gross yearly outlay of £250, including repayment of capital and interest. The price of 30s. per lamp was about half the cost of one gas burner, consuming 6ft. per hour, and used on an average six hours per day. If they put down an extra machine at a cost of £1,000 to provide 1,000 additional lights, a large profit would accrue, which would liquidate the capital sooner than 25 years, and when about half the 1,000 lights were taken up no doubt the town would be free from expense for its public lighting. The site suggested for a central station was a triangular piece of land enclosed by the pathway leading over Boardenbridge. The committee recommended that only the plant for the public lighting, and 300 private lamps should be put down first at a cost of £2,500, for building, machinery, plant, etc. If this was successful, extra plant could be added. With regard to raising the necessary funds, the committee pointed out that now the rates were lessened by £600 on account of the main road and police expenses, it would be possible to pay the amount of the outlay in four years, or it could be spread over a longer number of years. The gentleman who visited Bath with the committee and the surveyor explained Messrs. Todman's estimate, and after a great deal of consideration it was decided, on the motion of Mr. Mitchell, to postpone the matter for a fortnight, and it is understood that in the meantime a canvass of the town will be made to see how many are inclined to use electricity for private lighting.

THE EDINBURGH EXHIBITION.—XVIII.

The arrangement of the parts of Sir William Thomson's electrostatic balance is shown in Fig. 1. The fixed portion of the condenser in this instrument is a brass disc, B, which is supported from a slate base, S, on three glass pillars, P. The disc is provided with the well-known Thomson "hole, slot, and plane" arrangement, so that it always rests in exactly the same position on its supports.

A wire thickly covered with indiarubber passes from a terminal, T, through a glass tube, C, C, C, and makes connection with the disc by a spring contact, the glass tube being filled with paraffin to prevent the lodgment of moisture and give great resistance to disruptive discharge. A sheath formed by a short piece of glass tube pulls up over the terminal, T, and protects it from being touched by accident. The slate base-plate is provided with three screw levelling feet. A brass case fits upon the slate base-plate, and fixed to its top is a metal scale-box, with a glass front, which contains the indicator and scale. The movable part, V, is a round aluminium plate, supported by two long links, which pass through a slit in the top plate of the case to two knife-edge stirrups on one end of the counterpoised indicator, I. The whole movable portion is supported by knife-edges on two brass pillars, and has a short arm, A, with a knife-edge stirrup at its extremity attached to its axis. The weights which fix the constant of the instrument hang on this stirrup.

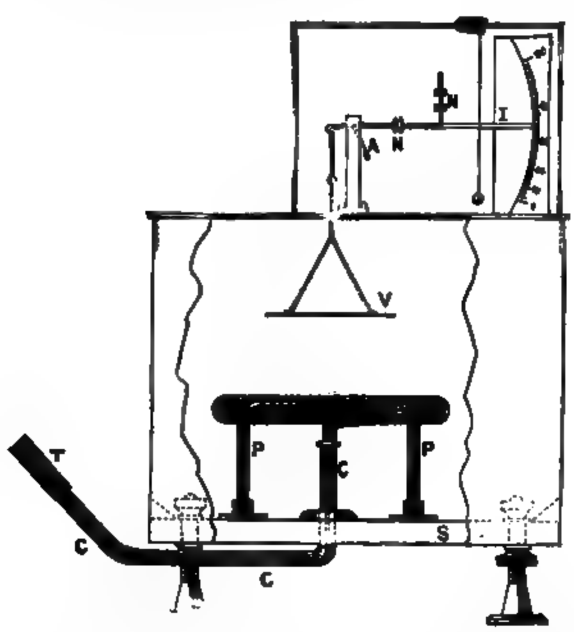


Fig. 1.—Sir William Thomson's Electrostatic Balance.

The instrument has a scale with divisions corresponding to equal differences of potential. The scale is graduated from 0 to 50, and three weights are provided such that, with the first alone hung on, the constant is 250 volts per division, with the first and second weights on, it is 500 volts per division, and with all three weights on 1,000 volts per division.

THE WALLER-MANVILLE CONDUIT SYSTEM.

We have several times referred to the conduit system of electric tramways devised by Messrs. Waller and Manville, which is being carried out by the Electrical Engineering Corporation, of which Mr. Manville is one of the directors. This system, it will be remembered, has for its features an open or slotted conduit with road plates and boxes at long intervals (30 yards or so) carrying oil insulators, which insulators require no other fixing than to be slipped into position when the road plates are lifted up; the cable or conductor lies unattached upon these insulators, and is lifted by the metallic collector (as shown in the figure) on the passing of each car and dropped gently down on the insulator arms again when the car has passed.

The arrangement inside the conduit are therefore extremely simple, and thoroughly good insulation is assured, the most peculiar part being the apparatus necessary to keep the conductor strained sufficiently tight so as not to

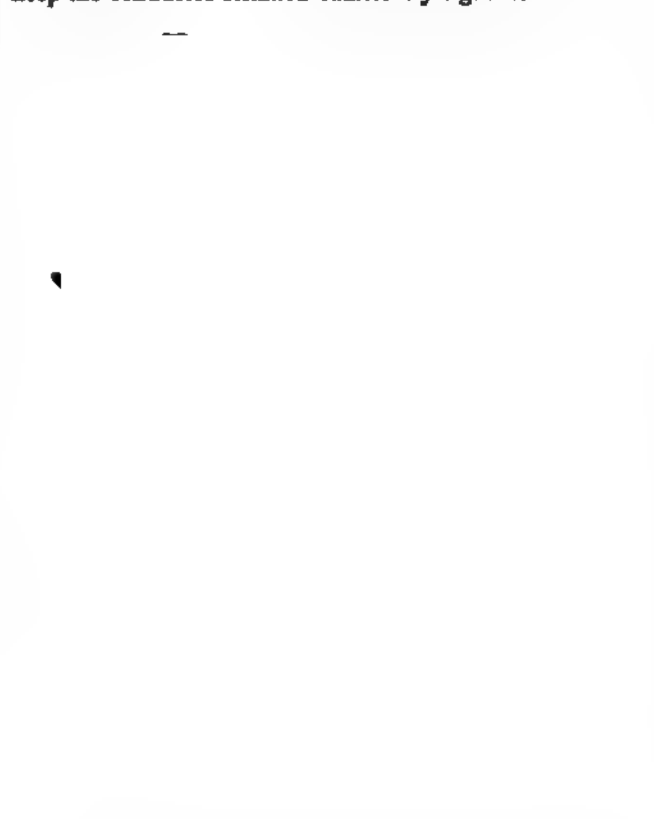


Fig. 1.—Waller-Manville Collecting Arm.

touch the bottom. Straining pieces would be placed at the interval of half a mile or so, and these also go into the space of the road-box mentioned, a pit being dug for the straining weight. The arrangement is very clearly shown in the accompanying figure, which shows the straining apparatus in perspective.

Fig. 2.—Waller-Manville Straining Apparatus.

The cable passes through corrugated grooves over two wheels inclined to each other, and through an eyelet hole, and then is attached to the straining weight, which is proportioned to the length of cable to be strained. The peculiarity of this arrangement is that as thus constructed the cable is kept taut, and at the same time—by the wheels

being mounted on pivoted arms in the manner shown—the cable and connecting part is raised to the required level by the collector of the passing car without altering the strain on the cable or moving the weight. The second length of cable is simply spliced to the metal piece, and has a similar straining piece at a further distance of half mile.

We understand that the patents for this system are allowed in Germany and America, and will be granted shortly; and that negotiations are in a forward condition for the establishment of a line on this system on the Continent. The slot conduit will be used in the town, and in less crowded parts or in the country parts between towns the overhead system will be connected, the car being furnished both with trolley-arm and slot-collector, so that the latter can be disconnected at the changing place.

CONTRIBUTIONS TO THE MOLECULAR THEORY OF INDUCED MAGNETISM.*

BY J. A. EWING, F.R.S., PROFESSOR OF ENGINEERING IN UNIVERSITY COLLEGE, DUNDEE.

(Concluded from page 269.)

There is some hysteresis during the removal (whether complete or partial) and reapplication of magnetic force, because (provided we have enough groups to deal with) there will be some lines of elements which pass to and fro through a condition of instability during the removal and reapplication of the force. For certain inclinations of the line, the movements are not reversible.

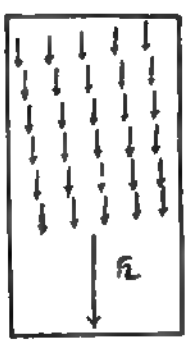


FIG. 6.

Suppose, next, that having applied and removed a strong force, $\mathfrak{H}$, leaving strong residual polarity, we begin slowly to reverse $\mathfrak{H}$. At first, the effects are slight; presently, however, instability begins, and, as the force is increased within a narrow range, we find the molecules all upset. This is followed by a stage of nearly elastic deflection as saturation is approached. Thus, the well-known general characteristics of cyclic processes are all reproduced in the model, see Fig. 8 below.

Again, a small repeated cyclic change of $\mathfrak{H}$ superposed upon a constant value of $\mathfrak{H}$ produces small changes of aggregate polarity, which are reversible if the change of $\mathfrak{H}$ is very small. This, as Lord Rayleigh has shown, is what happens in a magnetic metal, and the susceptibility with respect to small cyclic changes is small in the metal, just as it is in the actual solid.

The chief facts of permeability and retentiveness, and hysteresis generally, are therefore at once explicable by supposing that Weber's molecular magnets are constrained by no other forces than those due to their own mutual magnetic attractions and repulsions. No arbitrary constraining forces are required. In the model the centres of rotation are fixed; in regard to the actual solid we may make an equivalent supposition—namely, that the distances between the molecular centres do not change, except in so far as they may be changed by strain.

Hysteresis, then, is not the result of any quasi-frictional resistance to molecular rotations. It occurs whenever a molecule turns from one stable position of rest to another through an unstable condition. When it is forced to return, it again passes through a condition of instability. This process, considered mechanically, is not reversible. The forces are different for the same displacement, going and coming, and there is dissipation of energy. In the model, the energy thus expended sets the little bars swinging, and their swings take some time to subside. In the actual solid the energy which the molecular magnet loses as it swings through unstable positions generates eddy currents in surrounding matter. Let the magnets of the model be furnished with air vanes to damp their swings and the correspondence is complete.

A regular group of elementary magnets, especially when furnished with air vanes, gives a good illustration of what has been called magnetic viscosity. When the imposed force, $\mathfrak{H}$, reaches a critical value one of the outer members of the group becomes unstable, and swings slowly round; its next neighbours, finding their stability weakened, follow suit, and the disturbance spreads through the group in a way eminently suggestive of those phenomena of time-lag in magnetisation, which I have described in a former paper.

The model shows equally well other magnetic phenomena which presumably depend on the inertia of the molecules, such as the fact that a given force causes more magnetic induction when suddenly applied than when gradually applied, and leaves less residual magnetism when suddenly removed than when gradually removed.

The well-known effects of mechanical vibration in augmenting magnetic susceptibility and reducing retentiveness are readily explicable when we consider that vibration will cause periodic changes in the distances between molecular centres. This has not only a direct influence in making the molecular magnets respond more easily to changes of magnetic force by reducing their stability during the

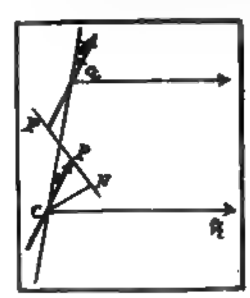


FIG. 7.

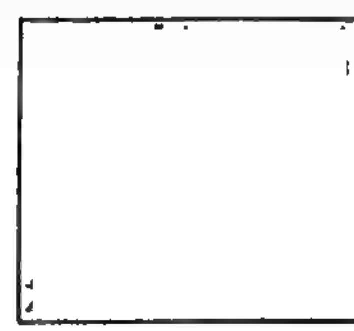


FIG. 8.

intervals when they recede from each other, but tends indirectly towards the same result by setting them swinging.

The effects of temperature which are common to the three magnetic metals may be stated thus: Let any moderate magnetising force be applied, not strong enough to produce anything like an approach to magnetic saturation, and let the temperature be raised. Then the permeability increases until the temperature reaches a certain (high) critical value, at which almost suddenly, there is an almost complete disappearance of magnetic equality. As regards the first effect, it is clear that an increase of permeability is to be expected from the theory. Expansion with rise of temperature involves a separation of the molecular centres, and therefore a reduction of stability. As regards the almost sudden loss of susceptibility which occurs at a high temperature, it may do no harm to hazard a rather wild conjecture. We may suppose the molecular magnets to be swinging more or less, the violence of the swings increasing as the temperature rises until finally it develops into rotation. Should this happen, all trace of polarity would, of course, disappear. The conjecture that the molecular magnets oscillate more and more as the temperature rises is at least supported by the fact (carefully investigated by Hopkinson in iron and nickel; data for cobalt also have lately been supplied by du Bois) that under strong magnetic forces rise of temperature reduces magnetism; for with strong forces the molecular magnets are already ranged, so that their mean direction is nearly parallel to $\mathfrak{H}$; hence the earlier effect of heat (to diminish stability and facilitate alignment) does not tell, and the increased swinging simply results in reducing the mean value for each molecule of its moment resolved parallel to the magnetising force.

* Paper read before the British Association.

Before referring to effects of stress we may consider shortly the stability of a pair or line of magnets, treating each as a pair of poles subject to the law of inverse squares. Take first a single pair of equal magnets with centres at C and C′, Fig. 7. The poles, P P′, would lie in the line, C C′, but for the imposed force, $\mathfrak{h}$, which produces a deflection, CC′P′ or C′CP $= \theta$.

Let a be the angle which $\mathfrak{h}$ makes with the line of centres, m the pole strength, and r the half length of the magnetic axis of each magnet. The deflecting moment is

$$2\,\mathfrak{h}\,m\,r\sin(a-\theta),$$

and the restoring moment is

$$\frac{m^2\,\overline{\mathrm{CN}}}{\overline{\mathrm{PP'}^2}},$$

C N being drawn normal to P P′. The restoring moment at first increases with θ, but passes a maximum at a value of θ which depends on the relation of r to the distance between the centres. The condition of equilibrium is

$$2\,\mathfrak{h}\,m\,r\sin(a-\theta)=\frac{m^2\,\overline{\mathrm{CN}}}{\overline{\mathrm{PP'}^2}};$$

and as $\mathfrak{h}$ and θ are increased the equilibrium becomes neutral, that is to say, the condition of instability is reached, when

$$\frac{d}{d\theta}\{2\,\mathfrak{h}\,m\,r\sin(a-\theta)\}=\frac{d}{d\theta}\frac{m^2\,\overline{\mathrm{CN}}}{\overline{\mathrm{PP'}^2}}.$$

These two equations serve to determine the value of $\mathfrak{h}$ and θ at which instability occurs. If we have to deal with a long line of magnets instead of a single pair, we have to write $2\,m^2$ instead of m^2 in the restoring moment.

A considerable amount of stable deflection is possible when the distance between the poles is not small compared with r. When the direction of $\mathfrak{h}$ is not much inclined to C C′ (that is, when a has a value approaching 0) there is no instability. In rows with various inclinations to $\mathfrak{h}$, the first to become unstable as $\mathfrak{h}$ is increased will be that for which $a-\theta$ is equal to $\frac{1}{2}\pi$.

If a, the half distance between the poles in the undeflected position, be small compared with r, there is but little deflection before instability occurs, and in that case, provided a be not small, nor nearly equal to π, the occurrence of instability is defined by the condition

$$\frac{d}{d\theta}\frac{\overline{\mathrm{CN}}}{\overline{\mathrm{PP'}^2}}=0,$$

which is satisfied when $\tan\phi=\frac{1}{\sqrt{2}}$; ϕ being the inclination of P P′ to the line of centres. Hence, with the same proviso (a not nearly equal to 0 or to π, and a small compared with r), the value of $\mathfrak{h}$ which causes the instability is

$$\mathfrak{h}=\frac{m}{12\sqrt{3}\,.\,a^2\sin a}$$

for a single pair of magnets, and twice this quantity for the middle members of a long row. This is, of course, least for magnets which lie normal to $\mathfrak{h}$.

In the special case when $a=\pi$, instability occurs when

$$\mathfrak{h}=\frac{m}{8a^2}$$

with the single pair, or $m/4\,a^2$ with the row.

Applied to the case of a group of rows, uniform in distance between the centres, but various as regards their direction with respect to $\mathfrak{h}$, these considerations show that after $\mathfrak{h}$ has reached a value sufficient to make the most susceptible members unstable, no very great increase is required to bring about instability in by far the greater number of the other rows. One general effect of increasing the distance between all the centres is to reduce the range of variation of $\mathfrak{h}$ within which most of the different rows become unstable as the force is progressively increased.

In annealed metal, where we may expect considerable general homogeneity, as regards distance between the centres of the molecular magnets, we find that practically the whole of the abrupt stage in the process of magnetisation is included within narrow limits of magnetising force. We accordingly obtain curves like A A, Fig. 8.

When the metal is strained sufficiently to receive permanent set the curves take more rounded outlines (such as B B), showing less susceptibility throughout, less residual magnetism, and more coercive force. The most natural explanation of this, on the basis of the molecular theory, appears to be that set produces on the whole a shortening of the distances between molecular centres, hence greater stability and more coercive force; but this is associated with heterogeneity, that is variety in the distances, hence the rounded outlines of the curves. We know that set tends to develop, or at least to emphasise, heterogeneity; for instance, a bar of iron or steel pulled in the testing machine stretches irregularly after the elastic limit is passed.

The effects of stress and consequent elastic strain on magnetic quality are so complex and so various in iron, nickel, and cobalt, that it would be premature to attempt any full discussion of them from the point of view of the theory now sketched. Only a few general features need be referred to at present. Some of these can be traced experimentally in the model by setting the supports of the magnets upon a sheet of thin indiarubber, which may be stretched or distorted to imitate the conditions of longitudinal or torsional strain.

When pulling stress is applied, those rows of molecular magnets which lie more or less along the direction of the stress have their stability reduced by the lengthening of the lines of centres. Similarly, rows which lie more or less normal to the stress have their stability increased. The resulting effect on the general susceptibility of the material will depend on which of these conflicting influences preponderates. Let pull be applied before magnetisation begins, while the metal is still in a neutral state. The stretching of longitudinal lines and the contraction of transverse lines will not only alter the stability of those molecules which continue to lie in their original rows, but will tend to make the members of those rows which are much lengthened swing round and form transverse lines in which they will be more stable than before. We may therefore reasonably expect that the permeability with regard to strong fields will be reduced by pull, as it actually is both in iron and in nickel, though with regard to weak fields the permeability may be increased, as it is in iron.

Again, the theory explains well why the effects of stress are by no means the same (1) when the stress is applied first and the magnetic force after, and (2) when the magnetic force is applied first and the stress after.

Let a moderate magnetising force be applied and then begin to apply stress. The first effects are in general large, for the strain precipitates into instability those molecular magnets which were already on the verge of instability. This is beautifully apparent in iron (see *Phil. Trans.*, 1885, part ii., plates 63 and 64); and the theory shows why the first effects are not reversible, why they do not disappear when the stress is removed, and why it is only in subsequent applications and removals of the stress that the magnetic changes become cyclic.

The same remark evidently applies to the first effects of stress on residual magnetism; also to the first effects of temperature change either on induced or residual magnetism. Again, the theory shows that when a cyclic change of stress is repeated there will be hysteresis in the corresponding changes of magnetism, whether induced or residual, unless either the cyclic range is very small or the magnetism approaches saturation. During each application of the stress some molecular magnets will swing through unstable positions; during the removal of stress they will swing back, but not at the same values of stress. And it will be characteristic of this hysteresis that the variation in magnetism will begin slowly when the change from applying to removing stress, or from removing to applying stress, begins. All this agrees with the facts.

Moreover, the theory shows that even in the absence of any resultant magnetisation a cycle of stress makes the molecular configuration pass through a series of changes which will at first not be cyclic, but will become cyclic when the stress cycle is repeated, and in which any intermediate value of the stress will be associated with different

configurations during the going and coming parts of the process. In other words, we see that there will be hysteresis in the relation of molecular configuration to stress when a cycle of stress is repeated. Hence, certain rather obscure effects which have been observed in magnetic experiments. For instance, where an iron wire is loaded and partially unloaded down to a given load before being magnetised, its permeability is not the same as when the wire is completely unloaded and reloaded up to the same load. Experimental results of this kind led me in 1884 to write: "If we apply and remove stress in a wire whose magnetic state is entirely neutral, we cause some kind of molecular displacement in the relation of which to the applied stress there is hysteresis." The theory now offered shows how this happens. Hence, also, the remarkable hysteresis which the thermoelectric quality of iron exhibits with regard to cyclic changes of stress, discovered by Cohn, and more fully described in *Phil. Trans.*, 1886, p. 361. The hysteresis of molecular configuration with respect to stress has been proved to be removable or reducible by vibration.

From this theoretical explanation of hysteresis in the effects of stress it at once follows that a cyclic change of stress, provided it be not very small, involves some dissipation of energy in a magnetic metal, whether the piece be magnetised or not. We may expect this dissipation to be most considerable under conditions which make the magnetic hysteresis large. But it will occur even when there is no external trace of magnetism.

This, of course, implies that in a cyclic process of loading and unloading work must be spent. There is no perfect elasticity in a magnetic metal, however slowly the process of straining be performed. Under any load there is less strain during application than during removal. This is borne out by experiments on the extension of iron wires (Brit. Assoc. report, 1889, p. 502).

The same action occurs to a marked degree in torsional strains. In a twisted specimen there will be a tendency on the part of the molecular magnets to range themselves along lines agreeing more or less with the direction of maximum contraction. Alternate twisting to opposite sides should therefore cause much molecular swinging through unstable positions, with consequent dissipation of energy, even in a piece which is not magnetised.

Without going at present into details, it may be added that the phenomena of molecular "accommodation" studied by Wiedemann and by H. Tomlinson accord with the theory, and that it seems to lend itself well to explain the very remarkable results which have been obtained by Nagoaka in experiments with nickel wire under twist or under a combination of pull and twist. It also agrees with what little is known as to the influence that previous magnetisation in one direction has upon subsequent magnetisation in another direction.

To sum up, I have endeavoured to show:

1. That in considering the magnetisation of iron and other magnetic metals to be caused by the turning of permanent molecular magnets, we may look simply to the magnetic forces which the molecular magnets exert on one another as the cause of their directional stability. There is no need to suppose the existence of any quasi-elastic directing force or of any quasi-frictional resistance to rotation.

2. That the intermolecular magnetic forces are sufficient to account for all the general characteristics of the process of magnetisation, including the variations of susceptibility which occur as the magnetising force is increased.

3. That the intermolecular magnetic forces are equally competent to account for the known facts of retentiveness and coercive force and the characteristics of cyclic magnetic processes.

4. That magnetic hysteresis and the dissipation of energy which hysteresis involves are due to molecular instability resulting from intermolecular magnetic actions, and are not due to anything in the nature of frictional resistance to the rotation of the molecular magnets.

5. That this theory is wide enough to admit explanation of the differences in magnetic quality which are shown by different substances or by the same substance in different states.

6. That it accounts in a general way for the known effects of vibration, of temperature, and of stress upon magnetic quality.

7. That in particular it accounts for the known fact that there is hysteresis in the relation of magnetism to stress.

8. That it further explains why there is in magnetic metals hysteresis in physical quality generally with respect to stress, apart from the existence of magnetisation.

9. That in consequence any (not very small) cycle of stress occurring in a magnetic metal involves dissipation of energy.

CORRESPONDENCE.

THEORY AND THE FERRANTI MAINS.

To the Editor of The Electrical Engineer.

Sir,—In your leader on the Ferranti mains, you begin "There is more work for the professors. No doubt we shall be told that all the observed phenomena due to high pressures and long lengths are only just what might have been expected." This seems to prove that those who require the spoon-feeding you ask for are in the position of the bad workman who abuses his tools. Such a one poses as "practical," and despises theory so much that he is unable to put it in practice. I trust neither Dr. Lodge nor any other "professor" will take any trouble to help those who pocket all the money, and give nothing but abuse to those who give them the tools they can only use badly. If Dr. Lodge were given £10,000, it might be worth his while licking the theory into such a shape that even practical men could use it.—Yours, etc.,

Geo. Fras. FitzGerald.

Trinity College, Dublin, 25th Sept., 1890.

P.S.—I do not, however, believe that your leader represents the views of those who are in the van in applying theory to supply the wants of mankind.

NEW FORMS OF ALTERNATORS.

To the Editor of The Electrical Engineer.

Sir,—As bearing upon this matter, some of your correspondents might be interested in looking over Jablochkoff's patent, No. 3,187 (1877). The designs described in this patent seemed to have forestalled all the more recent ideas on the subject.—Yours, etc., R. C. Jackson.

Pandon Dene, Newcastle-upon-Tyne, Sept. 29th, 1890.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

Lecture I.—Historical Sketch.

(*Continued from page 274.*)

"In describing the results of my experiments, the terms 'intensity' and 'quantity' magnets were introduced to avoid circumlocution, and were intended to be used merely in a technical sense. By the intensity magnet I designated a piece of soft iron, so surrounded with wire that its magnetic power could be called into operation by an intensity battery; and by a quantity magnet, a piece of iron so surrounded by a number of separate coils, that its magnetism could be fully developed by a quantity battery.

"I was the first to point out this connection of the two kinds of the battery with the two forms of the magnet, in my paper in *Silliman's Journal*, January, 1831, and clearly to state that when magnetism was to be developed by means of a compound battery one long coil must be employed, and when the maximum effect was to be produced by a single battery a number of single strands should be used. . . . Neither the electromagnet of Sturgeon nor any electromagnet ever made previous to my investigations was applicable to transmitting power to a distance. . . . The electromagnet made by Sturgeon, and copied by Dana, of New York, was an imperfect quantity magnet, the feeble power of which was developed by a single battery."

Finally, Henry sums up his own position as follows:

"1. Previous to my investigations the means of developing

* Cantor Lecture, delivered before the Society of Arts.

magnetism in soft iron were imperfectly understood, and the electromagnet which then existed was inapplicable to transmissions of power to a distance.

"2. I was the first to prove by actual experiment that in order to develop magnetic power at a distance, a galvanic battery of 'intensity' must be employed to project the current through the long conductor, and that a magnet surrounded by many turns of one long wire must be used to receive this current.

"3. I was the first to actually magnetise a piece of iron at a distance, and to call attention to the fact of the applicability of my experiments to the telegraph.

"I was the first to actually sound a bell at a distance by means of the electromagnet.

"The principles I had developed were applied by Dr. Gale to render Morse's machine effective at a distance."

Though Henry's researches were published in 1831, they were for some years almost unknown in Europe. Until April, 1837, when Henry himself visited Wheatstone at his laboratory at King's College, the latter did not know how to construct an electromagnet that could be worked through a long-wire circuit. Cooke, who became the coadjutor of Wheatstone, had originally come to him to consult him, in February, 1837, about his telegraph and alarum, the electromagnets of which, though they worked well on short circuits, refused to work when placed in circuit with even a single mile of wire. Wheatstone's own account of the matter is extremely explicit: "Relying on my former experience, I at once told Mr. Cooke that his plan would not and could not act as a telegraph, because sufficient attractive power could not be imparted to an electromagnet interposed in a long circuit; and, to convince him of the truth of this assertion, I invited him to King's College to see the repetition of the experiments on which my conclusion was founded. He came, and after seeing a variety of voltaic magnets, which even with powerful batteries exhibited only slight adhesive attraction, he expressed his disappointment."

After Henry's visit to Wheatstone the latter altered his tone. He had been using, *faute de mieux*, relay circuits to work the electromagnets of his alarum in a short circuit with a local battery. "These short circuits," he writes, "have lost nearly all their importance, and are scarcely worth contending about since *my discovery*" (the italics are our own) "that electromagnets may be so constructed as to produce the required effects by means of the direct current, even in very long circuits."

We pass on to the researches of the distinguished physicist of Manchester, whose decease we have lately had to deplore, Mr. J. P. Joule, who, fired by the work of Sturgeon, made most valuable contributions to the subject. Most of these were published either in Sturgeon's "Annals of Electricity," or in the *Proceedings* of the Literary and Philosophical Society of Manchester, but their most accessible form is the republished volume issued five years ago by the Physical Society of London.

In his earliest investigations he was endeavouring to work out the details of an electric motor. The following is an extract from his own account ("Reprint of Scientific Papers," p. 7):

"In the further prosecution of my enquiries I took six pieces of round bar iron of different diameters and lengths, also a hollow cylinder, 1-13th of an inch thick in the metal. These were bent in the U-form, so that the shortest distance between the poles of each was $\frac{1}{2}$in. Each was then wound with 10ft. of covered copper wire, 1-40th of an inch in diameter. Their attractive powers under like currents for a straight steel magnet, $1\frac{1}{2}$in. long, suspended horizontally to the beam of a balance, were at the distance of $\frac{1}{2}$in. as follows:

—	No. 1. Hollow.	No. 2. Solid.	No. 3. Solid.	No. 4. Solid.	No. 5. Solid.	No. 6. Solid.	No. 7. Solid.
Length round the bend in inches	6	$5\frac{1}{2}$	$2\frac{1}{4}$	$5\frac{1}{4}$	$2\frac{1}{2}$	$5\frac{1}{4}$	$2\frac{1}{4}$
Diameter in inches	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{4}$
Attraction for steel magnet in grains	7·5	6·3	5·1	5·0	4·1	4·8	3·6
Weight lifted, in ounces............	36	52	92	36	52	20	28

"A steel magnet gave an attractive power of 23 grains, while its lifting power was not greater than 60oz.

"The above results will not appear surprising if we consider, first, the resistance which iron presents to the induction of magnetism, and, second, how very much the induction is exalted by the completion of the magnetic circuit.

"Nothing can be more striking than the difference between the ratios of lifting to attractive power at a distance in the different magnets. Whilst the steel magnet attracts with a force of 23 grains and lifts 60oz., the electromagnet No. 3 attracts with a force of only 5·1 grains, but lifts as much as 92oz.

"To make a good electromagnet for lifting purposes: 1st, Its iron, if of considerable bulk, should be compound, of good quality, and well annealed. 2. The bulk of the iron should bear a much greater ratio to its length than is generally the case. 3rd. The poles should be ground quite true, and fit flatly and accurately to the armature. 4th. The armature should be equal in thickness to the iron of the magnet.

"In studying what form of electromagnet is best for attraction from a distance, two things must be considered—viz., the length of the iron, and its sectional area.

"Now, I have always found it disadvantageous to increase the length beyond what is needful for the winding of the covered wire."

These results were announced in March, 1839. In May of the same year Joule propounded a law of the mutual attraction of two electromagnets, as follows: "The attractive force of two electromagnets for one another is directly proportional to the square of the electric force to which the iron is exposed; or if E denote the electric current, W the length of wire, and M the magnetic attraction, $M = E^2 W^2$." The discrepancies which he himself observed he rightly attributed to the iron becoming saturated magnetically. In March, 1840, he extended this same law to the lifting power of the horseshoe electromagnet.

In August, 1840, he wrote to the "Annals of Electricity," on electromagnetic forces, dealing chiefly with some special electromagnets for traction. One of these possessed the form shown in Fig. 7. Both the magnet and the iron keeper were furnished with eye-holes for the purpose of suspension and measurement of the force requisite to detach the keeper. Joules thus writes about the experiments.

"I proceed now to describe my electromagnets, which I constructed of very different sizes in order to develop any curious circumstance which might present itself. A piece of cylindrical wrought iron, 8in. long, had a hole 1in. in diameter, bored the whole length of its axis; one side was planed until the hole was exposed sufficiently to separate the thus-formed poles one-third of an inch. Another piece of iron, also 8in. long, was then planed, and being secured with its face in contact with the other planed surface, the whole was turned into a cylinder 8in. long,

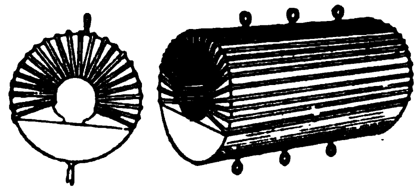


Fig. 7.—Joule's Electromagnet.

$3\frac{3}{4}$in. in exterior, and 1in. interior diameter. The larger piece was then covered with calico and wound with four copper wires covered with silk, each 23ft. long, and 1-11th of an inch in diameter—a quantity just sufficient to hide the exterior surface, and to fill the interior opened hole." . . . "The above is designated No. 1; and the rest are numbered in the order of their description."

"I made No. 2 of a bar of $\frac{1}{2}$in. round iron 2·7in. long. It was bent into an almost semi-circular shape, and then covered with 7ft. of insulated copper wire 1-20th of an inch thick. The poles are $\frac{1}{2}$in. asunder, and the wire completely fills the space between them.

"A third electromagnet was made of a piece of iron 0·7in. long, 0·37in. broad, and 0·15in. thick. It edges were reduced to such an extent that the transverse section was elliptical. It was bent into a semi-circular shape, and wound with 19in. of silked copper wire 1-40th of an inch in diameter.

"To procure a still more extensive variety I constructed what might from its extreme minuteness be termed an elementary electromagnet. It is the smallest, I believe, ever made, consisting of a bit of iron wire $\frac{1}{4}$in. long and 1-25th of an inch in diameter. It was bent into the shape of a semicircle, and was wound with three turns of uninsulated copper wire 1-40th of an inch in thickness."

With these magnets experiments were made with various strengths of currents, the tractive forces being measured by an arrangement of levers. The results, briefly, are as follows: Electromagnet No. 1, the iron of which weighed 15lb., required a weight of 2,090lb. to detach the keeper. No. 2, the iron of which weighed 1,057 grains, required 49lb. to detach its armature. No. 3, the iron of which weighed 65·3 grains, supported a load of 12lb., or 1,286 times its own weight. No. 4, the weight of which was only half a grain, carried in one instance 1,417 grains, or 2,834 times its own weight.

"It required much patience to work with an arrangement so minute as this last, and it is probable that I might ultimately have obtained a larger figure than the above, which, however, exhibits a power proportioned to its weight far greater than any on record, and is 11 times that of the celebrated steel magnet which belonged to Sir Isaac Newton.

"It is well known that a steel magnet ought to have a much greater length than breadth or thickness, and Mr. Scoresby has found that when a large number of straight steel magnets are bundled together, the power of each when separated and examined is greatly deteriorated. All this is easily understood, and finds its cause in the attempt of each part of the system to induce upon the other part a contrary magnetism to its own. Still, there is no reason why the principle should in all cases be extended from the steel to the electromagnet, since in the latter case a great and commanding inductive power is brought into play to sustain what the former has to support by its own unassisted retentive property. All the preceding experiments support this position, and the following table gives proof of the obvious and necessary general consequence, the maximum power of the electromagnet is directly proportional to its least transverse sectional area. The second column of the table contains the least sectional area in square inches of the entire magnetic circuit. The maximum power in pounds avoirdupois is recorded in the third; and this, reduced to an inch square of sectional area, is given in the fourth column under the title of specific power."

TABLE I.

Description.		Large sectional area.	Maximum power.	Specific power.
My own electromagnets	No. 1...	10	2090	209
	No. 2...	0·196	49	250
	No. 3...	0·0436	12	275
	No. 4...	0·0012	[illegible]	162
Mr. J. C. Nesbit's. Length round the curve, 3ft.; diam. of iron core, 2¾in.; sectional area, 5·7in.; do. of armature, 4·5in.; weight of iron, about 50lb.		4·5	1428	317
Prof. Henry's. Length round the curve, 20in.; section, 2in. square; sharp edges rounded off; weight, 21lb.		3·94	750	190
Mr. Sturgeon's original. Length round the curve, about 1ft.; diam. of the round bar, ½in...		0·196	50	255

"The above examples are, I think, sufficient to prove the rule I have advanced. No. 1 was probably not fully saturated, otherwise I have no doubt that its power per square inch would have approached 300. Also, the specific power of No. 4 is small, because of the difficulty of making a good experiment with it."

These experiments were followed by some to ascertain the effect of the length of the iron of the magnet, which he considered, at least in those cases where the degree of magnetisation is considerably below the point of saturation, to offer a decidedly proportional resistance to magnetisation, a view the justice of which is now, after 50 years, amply confirmed.

In November of the same year further experiments in the same direction were published. A tube of iron, spirally made and welded, was prepared, planed down as in the preceding case, and fitted to a similarly prepared armature. The hollow cylinder thus formed, shown in Fig. 8, was 2ft. in length, its internal diameter was 1·42in., its internal being 0·5in. The least sectional area was 10¼ square inches. The exciting coil consisted of a single copper rod, covered with tape, bent into a sort of S-shape. This was later replaced by a coil of 21 copper wires, each 1·25in. in diameter and 23ft. long, bound together

FIG. 8.—Joule's Cylindrical Electromagnet.

by cotton tape. This magnet, excited by a battery of 16 of Sturgeon's cast-iron cells, each 1ft. square and 1¼in. in interior width, arranged in a series of four, gave a lifting power of 2,775lb.

Joule's work was well worthy of the master from whom he had learned his first lesson in electromagnetism. He showed his devotion, not only by writing descriptions of them for Sturgeon's "Annals," but by exhibiting two of his electromagnets at the Victoria Gallery of Practical Science, of which Sturgeon was director. Others, stimulated into activity by Joule's example, proposed new forms, amongst them being two Manchester gentlemen, Mr. Radford and Mr. Richard Roberts, the latter being a well-known engineer and inventor. Mr. Radford's electromagnet consisted of a flat iron disc, with deep spiral groves cut in its face, in which were laid the insulated copper wires. The armature consisted of a plain iron disc of similar size. This form is described in vol. iv. of Sturgeon's "Annals." Mr. Roberts's form of electromagnet consisted of a rectangular iron block, having straight parallel grooves cut across its face, as in Fig. 9. This was described in vol. vi. of Sturgeon's "Annals," p. 166. Its face was 6⅜in. square, and its thickness 2 7-16in. It weighed, with the conducting wire, 35lb.; and the armature, of the same size and 1½in. thick, weighed 23lb. The load sustained by this magnet was no less than 2,950lb. Roberts inferred that a magnet, if made of equal thickness, but 5ft. square, would sustain 100 tons' weight. Some of Roberts's apparatus is still preserved in the museum of Peel Park, Manchester.

On p. 431 of the same volume of the "Annals," Joule described yet another form of electromagnet, the form of which resembled in general Fig. 10; but which, in actual fact, was

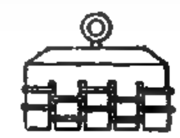


FIG. 9.—Roberts's Electromagnet.

built up of 24 separate flat pieces of iron bolted to a circular brass ring. The armature was a similar structure, but not wound with iron. The iron of the magnet weighed 7lb., and that of the armature 4·55lb. The weight was 2,710lb. when excited by 16 of Sturgeon's cast-iron cells.

In a subsequent paper on the calorific effects of magneto-electricity, published in 1843, Joule described another form of electromagnet of horseshoe shape, made from a piece of boiler-plate. This was not intended to give great lifting power, and was used as the field magnet of a motor. In 1852 another powerful electromagnet of horseshoe form, somewhat similar to the preceding, was constructed by Joule for experiment. He came to the conclusion that owing to magnetic saturation setting in, it was improbable that any force of electric current could give a magnetic attraction greater than 200lb. per square inch. "That is, the greatest weight which could be lifted by an electromagnet formed of a bar of iron 1in. square, bent into a semi-circular shape, would not exceed 400lb."

With the researches of Joule may be said to end the first stage of development. The notion of the magnetic circuit which had thus guided Joule's work did not commend itself at that time to the professors of physical theories, and the practical men, the telegraph engineers, were for the most part content to work by purely empirical methods. Between the practical man and the theoretical man there was, at least on this topic, a great

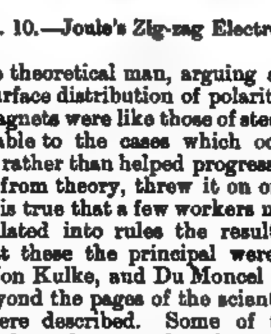


FIG. 10.—Joule's Zig-zag Electromagnet.

gulf fixed. The theoretical man, arguing as though magnetism consisted in a surface distribution of polarity, and as though the laws of electromagnets were like those of steel magnets, laid down rules not applicable to the cases which occur in practice, and which hindered rather than helped progress. The practical man, finding no help from theory, threw it on one side as misleading and useless. It is true that a few workers made careful observations and formulated into rules the results of their investigations. Amongst these the principal were Ritchie, Robinson, Müller, Dub, Von Kulke, and Du Moncel; but their work was little known beyond the pages of the scientific journals wherein their results were described. Some of these results will be examined in my later lectures, but they cannot be discussed in this historical *résumé*, which is accordingly closed.

(To be continued.)

THE

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PRACTICAL v. PROFESSIONAL.

Prof. FitzGerald has touched upon a subject which to safely unravel is beyond our powers. There are too many men on both sides ready to imagine a reference is directly made against the individual rather than against the system, and there is no doubt the most delighting controversy to the outsider is that of the swashbuckling kind, singling out individuals and hitting them with all possible energy. This method is very effective if you can only choose your antagonist; then, of course, one would naturally be chosen that would not have the ghost of a chance against the attack. In such a case, Prof. FitzGerald would be safe against attack. He is a strong and doughty adversary against whom little progress would be made, and who could and would drive home some very awkward blows. The first aim of controversialists should be to find some common starting point. If there is no common ground, no position about which all are agreed, words are so much wind—they blow, and no one knows whence they come or what they mean: the result is pretty much as you were, except that tempers are ruffled, and ofttimes friendships imperilled. Our fundamental conception of the genus professor is probably not that of Prof. FitzGerald. Briefly, we look upon a professor as an educational medium, and a seeker after truth. His place is in the laboratory, the professional chair, and the library—an original worker, a teacher verbally, and by means of books. His remuneration, if we had our way, should be greater than that of any average professional man. We shall not preclude either the professional man or the commercial man possessing exceptional ability and gaining exceptional results. The professor should be amply rewarded—sufficiently so to make the looking after money unnecessary. We should be delighted to see such a man as Dr. Lodge in a chair with £10,000 a year attached to it. He is worth it—but that is an aside. Under our ideal, we should, as we do now, strongly and strenuously object to professors mixing themselves up in business matters, acting the Jekyll and Hyde manner—now a professor whose position is beyond reproach, now a consulting engineer writing reports for every comer willing to pay a certain fee. There is hardly a patent tried to be foisted upon the community by company promoters but is reported upon satisfactorily by hybrid professors. Once more our remarks are not to be taken against individuals. If a man is worth £5,000 a year, and his country gives him a professorship of £500, the man has to make the remaining £4,500 somehow. He makes it by "consulting work." The position is a painful one. The real consulting engineer says: I have to pay office expenses, pay a staff of assistants, and a great deal more, and have to compete against men whose laboratory and all its contents

are supplied with public money; whose assistants pay to work in the public laboratory, yet are put to work upon that which brings a consulting fee into an individual's pocket, an individual also who is paid a salary out of public funds. The electrical industry is particularly subject to the domination of the hybrid professor consulting engineer, and the work he performs of this composite nature is about as bad as it can be. Thus far we have stated some views as to what a professor should do and what he should not do. Another point of difference refers to what Prof. FitzGerald terms spoon-feeding. This is an expressive, but not an appropriate phrase. With very few exceptions—but these exceptions are amongst the most brilliant authorities in the world's history—the spoon-feeding is the other way about, from the practical to the professional side. Thus differently do different men view the same thing. Our contention is that generally the practical worker—frequently according to the professional dictum the uneducated workman—manages somehow to scheme out something new. The apparatus so schemed out has the one great merit that it works, but we admit is seldom perfect. Now that the nut has been cracked, the professors step in and examine the kernel, and tell us how it is that it works. They tackle the theory, they look at it analytically, they look at it synthetically; they usually find that the theories held at the time of the discovery are incompetent to explain the whole subject; they modify, they curtail, they extend the theories till they make one that fits the case—just as the Mikado made a punishment fit the crime. We hold that this making of theories to fit advanced practice is pretty much what professors are built for.

In electrical matters theory has not been projected forward—it has hardly caught up advanced practice. Indeed, we know of no theory that is perfectly satisfactory, though if an exception is to be made let it be that of gravitation. To sum up thus far, we contend that it is not only the duty, it is the privilege of professordom, constituted as it is at the public expense, to explain as expeditiously and as simply as it can any phenomena which may be noticed in carrying out practical work. The practical man may have held the purse strings too tightly, but has he done nothing at Newcastle, at Leeds, at Manchester, at Liverpool, at Nottingham, Birmingham, Bristol, and a dozen other places? He may think £300 a year and class fees enough for a professor, but that is partly the professor's fault. At any rate, this shows he is not pocketing all the money and giving nothing. Finally, according to our view, Prof. FitzGerald's postscript falls harmless, even if the opinions expressed are single, rather than multiple. The practical electrician has had but little theory to apply; he has, without much theory, made apparatus to work, and the professors have subsequently applied theories to that apparatus, satisfactory, perhaps, in a way, sometimes so as a working theory—hardly, however, calculated to last long without considerable modifications. The practical man is supplying "facts," from these facts generalisations are being made and laws deduced, more facts mean frequently modifications of these deductions, and so the world of theory goes on.

AUTOMATIC.

The automatic machines so conspicuous at all railway stations ought to have suggested to electrical apparatus makers a field wherein good work may be done. The penny-in-the-slot arrangement has been utilised for giving light to railway travellers, but with the introduction of light in houses should go contemporaneously the use of motors. Take hotel requirements, for example. A small motor that could be switched on or off could be made to drive boot brushes, and any visitor could have his boots brushed at any time. One or two such machines at the railway stations would probably be well patronised by travellers, and get rid of what is ofttimes a nuisance—the bootblack. A penny for a shine is the nominal charge, but a large number of those who patronise the bootblack bestow more than one penny for the labour. Knife-cleaning machines, again, could easily be fitted with a motor, as could many other machines used in hotels and in shops. We have heard many curious tales about the impossibility of getting what was wanted in the way of electrical apparatus, and it may be assumed that the field for these small motors has not received the attention it deserves, at any rate not outside of America and American agents. Young and enterprising firms might do worse that make a speciality of the introduction of small motors and apparatus connected therewith.

THE VAUGHAN-SHERRIN ELECTRIC TRICYCLE AND BOAT.

We have been up this week to 48, Eagle-wharf-road, Hoxton, the offices of the Henry Rifled Arms Company, to inspect an electric tricycle and an electric launch driven by a new primary battery and motor devised by Mr. Vaughan-Sherrin, electrical engineer, of Ramsgate. We propose to simply say what we saw and what Mr. Vaughan-Sherrin said. We have seen primary batteries in scores rise, glitter for a moment, and fall, not to be heard of again. All we can say of Mr. Vaughan-Sherrin's battery at the present is that it is compact, evidently powerful, constant, and handy, and it has received very flattering reports from Prof. Silvanus Thompson, and Mr. Kempe, of the Post Office, and has, besides, received considerable attention from would-be users.

The electric tricycle shown, or Bath chair rather, is a wickerwork chair on three indiarubber-tyred wheels, with front steering. A tray is fitted by springs behind, and on this are placed two narrow boxes of cells about 2ft. long and 8in. or 10in. high, each containing nine cells of the new battery. A specially constructed and neat little motor is geared by chains to the tricycle driving wheel. The whole

arrangement in the trial Bath chair is yet rather crude and rough, but the Bath chair goes, and goes very well, and the electric part of the arrangement certainly does not seem excessively large; in fact, is much about the size that the purchaser of an electric tricycle might expect it to be. We had a ride in this extemporised electric chair, and found it went along the level road at a very smart walking pace—some five miles an hour—and mounted the slight hills that were tried at a slow walking pace; in fact, did what an electric Bath chair should do.

The battery is a double-fluid battery of carbon plates and zinc plates placed very close together. One fluid is plain water and the other a "special" solution, of nature not disclosed. Mr. Vaughan-Sherrin states that he has tried all known kinds of primary batteries in the attempt to drive his tricycle, and has devised a battery which will give a strong current of eight amperes—or a sudden discharge for uphill work of up to 25 amperes—at a very small cost; including chemicals and plates, 2d. an hour all round is what he has calculated the cost, and the battery will last for a run of nine hours. The voltage of the battery is high—2·1 volts, or, say, 1·8 volts on discharge. The two boxes of 18 cells give 30 available volts, and weigh altogether 80lb., which is sufficient for a day's run on the tricycle, the cost being thus given at 1s. 6d. for the nine hours. Mr. Vaughan-Sherrin says he will undertake to supply chemicals and materials in any quantity to carry out this estimate, and it is to be hoped he will be able to do so. At anything approaching such a figure the demand for electric tricycles and invalid chairs would be very great. He says that as yet it is found impossible to obtain an electric tricycle in the market; he has tried himself, and no one will undertake to produce an electrically-driven vehicle at reasonable cost for running, and without the necessity for dynamos and engines for charging stations. Rudge, the bicycle makers, have, it is said, been offered some thousands of pounds for a good electric machine and could not supply it. Mr. Vaughan-Sherrin maintains he has the article. He has formed a company with a capital of £25,000, of which he states all but £2,000 is already subscribed, and is intending to start works for the manufacture of batteries, motors, and electric tricycles, electric Bath chairs, electric carriages, and electric boats, as well as the supply of motors and batteries for any light mechanical work. He says that orders for tricycles, chairs, and boats have already been coming in rapidly, and that over a thousand pound's worth of orders have been received; he will soon have to refuse to book orders.

We were afterwards treated to a ride in the primary battery electric boat. The two boxes of cells used in the tricycle were lifted out, and a third added and placed in the boat. This electric boat, which was shown at Henley last regatta, has a small propeller geared by chain gearing to a small ½-h.p. motor, and ran at a very fair pace—quite as quick as boats on the Thames want to progress. We had a row up the canal and back on this boat. The cost for this is given at 3d. an hour, the weight of battery being 120lb., lasting nine hours. Afterwards we inspected the large launch which he has also fitted up, and has used at Ramsgate.

Mr. Vaughan-Sherrin promises to take a run with his large launch across from Dover to Calais with primary batteries, and some big social and electrical men are, he says, to be invited. He states that at need material for a 600-mile run can be stowed on board.

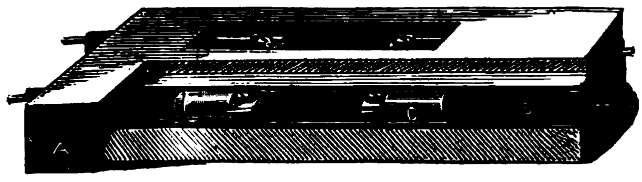
Arrangements are also made for the trial of the battery and motor in tramcar driving, where the small weight of the battery would be an advantage. If only Mr. Vaughan-Sherrin can carry out his little plan, how simple electric traction would all become. It is all a question of economics, however. If this battery can produce its electricity at 9d. or 10d. a unit, as Mr. Vaughan-Sherrin says he has proved he can and will undertake to carry out, why all we can do is to wish to see him do it. Not the least satisfactory part of the matter is that the company does not want money, but wants works; and the arrangements, we are told, are nearly complete for this; then it is business they will want.

The price of the electric tricycle is to be only £30 complete, with motor and battery; and the number of people who will buy these novelties, even if the maintenance should be twice or three times as much as the small sum mentioned, and in spite of the joltings about of chemicals, may quite conceivably be large enough to employ a tricycle-battery-motor works as a speciality—to say nothing of larger game of launches and tramcars hinted at.

It is therefore to be hoped that the company will not lose their £25,000 before they have convinced us of their claim that the Vaughan-Sherrin motor is a serviceable and economical combination for small power.

THE CHAMPION CUT-OUT.

We herewith illustrate a cut-out which is being introduced by Mr. Todman, which he calls the "Champion" cut-out. The diagram will explain itself. A shows the wood casing, B the line wire, and C the cut-out. The



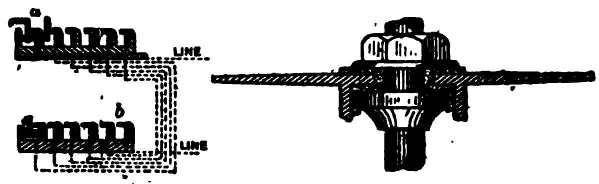
latter is composed of two brass ends, to which the line wire is soldered. These ends are joined by a slip of vulcanised fibre, and the fuse wire is fixed under the two screws as shown. A glass globe covers the fuse and connection, and when it is necessary to replace the fuse the tube slides along the wire.

SOME NEW FORMS OF DYNAMOS.*

BY F. L. O. WADSWORTH.

(Concluded from page 265.)

Fig. 6 is a cross-section through the centre of the armature and field of a six-pole machine, showing the arrangement of the windings of the exciting coil and the magnetic circuit. It will be seen that the arrangement of the windings is such that for those which produce the interior poles there is no external field. In the case of the exterior windings this is true of one side of the coil (that next to the armature) only. The windings being brought out flush with the pole-pieces, prevent a direct passage of the lines



Figs. 4 and 5.—Connections of Disc Armature.

of force between the poles, the outer layers of wire serving to force the lines through the armature. The poles may therefore be brought very close to each other, and all the advantages of M. Mariotti's arrangement realised.

The amount of dead wire on the armature becomes very small indeed, much less than is necessary on a drum armature of the most favourable type of construction, and the output of the machine per pound of copper used is by that much increased. There is nothing more difficult in the mechanical construction than in the case of the ordinary machine. The inner field, armature core, and outer field may be stamped with little loss out of the same disc of sheet iron, even for large machines. There are no joints in the magnetic circuit, and it is moreover very short; therefore few ampere-turns on the field will be required. Either the armature or the field magnets might revolve as desirable, as the whole construction is symmetrical about the centre of rotation.

If poles on one side of the armature only are employed, there are several reasons why internal are preferable to

* From the *Electrical World*, New York.

external poles. The magnetic circuit is much shorter, the windings are completely surrounded with iron, and the field is of such a form that it may be made without joints and of wrought iron, either solid or laminated. The winding of the field is very easy; in fact, the winding on a two-pole machine is the same as that on the old form of Siemens "shuttle" armature. In addition to these advantages, the armature may be made of very large size (in fact, the diameter would necessarily be greater than in machines with external poles) without increasing the size of the machine, the external dimensions of the armature determining, in fact, the external dimensions of the machine.

Fig. 6.—Modified Gramme Dynamo.

This possible increase of size means, of course, a possible decrease of the speed of rotation, for with a given inductor velocity the angular velocity varies inversely as the diameter of the armature. With this construction it is possible, even desirable, to rotate the field magnets rather than the armature; and although the windings of the field are also in motion, there is little trouble in securing them in such a way that there is no danger of their becoming loosened.

The clearness between the pole-pieces and the armature wires may, as in the case of all machines in which the armature wires are stationary, be reduced to the smallest possible amount. Even if the armature be revolved instead of the field, centrifugal force keeps the armature coils pressed against the cores and away from the field instead of the reverse, avoiding all danger of ruining the armature by breaking the binding wires. Other mechanical advantages might be mentioned, such as best possible ventilation of the armature, easy removal, or replacement of any of the armature coils, etc.; but enough has been said to call attention to some of the more important advantages of this type of construction. On the other hand, it may be said

Figs. 7 and 8.—Modified Drum Armature Dynamo.

that the armature is more liable to accidental injury, that the iron of the field will be heated somewhat more by the current in the exciting coils, because of its enclosed position, and that revolving brushes are objectionable because they require an additional pair of collecting rings.

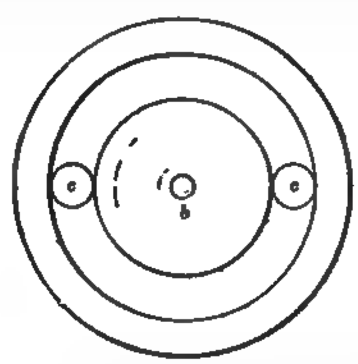
From the last described form we pass easily to another in which the armature is of the drum type. The relative position of the field and armature core is the same as before, and the same statements would apply to this as to the preceding machine. The armature could be wound by placing the two end pieces, *a a* (Fig. 7), in position, winding on the wire as usual, and then slipping the armature core over the windings. When finished the field would be completely enclosed, and it would be impossible to obtain access to it without unwinding a portion of the armature. The field would therefore have to be wound very carefully and securely in order to prevent the necessity for any such proceeding.

This form may be again slightly modified so as to give us that shown in Fig. 9. In this the armature has no iron core, but is built up of commutator-shaped bars connected across the ends by wires or discs. The outer shell of iron revolves with the inner field, and there is therefore no reversal of magnetisation in any part of the field and no external field. There is necessarily a double air gap, but the additional air space thus introduced is slight, because the clearance may be made less than that allowable when

Fig. 9.—Simple Dynamo.

wire windings are used and the thickness of the insulation between two layers of wire is saved. Whether, however, the advantages to be gained from the elimination of hysteresis would compensate commercially the somewhat increased cost of construction can only be answered when special conditions are assumed.

It will be noticed that all of the forms so far described are equally symmetrical about the axis of rotation, so that either field or armature might revolve. In case of some dynamo and most motor work it seems desirable that both armature and field should revolve in opposite directions. If the angular velocity of the two be numerically equal the result will be that with the same rate of cutting of lines of force—viz., with the same winding and output—the speed will be reduced 50 per cent. This reduction will in many cases enable existing types of motors to be placed directly on the shaft of the driven machine without the use of intermediate gearing or belting. This arrangement applied to Dr. Duncan's remarkable motor would give a speed of only 45 revolutions per minute.



Figs. 10 and 11.—Motor Gearing.

The means by which combined rotary action in opposite directions may be obtained are readily devised. One of the most simple arrangements is that shown in Fig. 10, the outer annular gear being attached, say, to the field and driven pulley, the inner gear, *b*, to the armature and the two pinions, *c c*, to the frame or some stationary portion of the machine. Each of the pinions, *c c*, only has to transmit one-quarter of the power of the motor; the wear would therefore be light; indeed for light or even moderately heavy work gears might be replaced by friction cones, made as shown in Fig. 11, the construction being such that any desired degree of pressure between the driving surfaces

may be obtained without any thrust on either bearing, and any wear readily taken up. With this arrangement the angular velocity of armature and field is not quite the same, but may be made very nearly the same by making a and b of sufficient size. Exact equality is not however necessary.*

In street car work both axles could be driven directly from one motor without any rigidity or hard driving action by attaching one axle directly to either armature or field and the other axle to field or armature; any irregularity of motion between the two is then perfectly provided for without the use of springs or other perishable arrangements

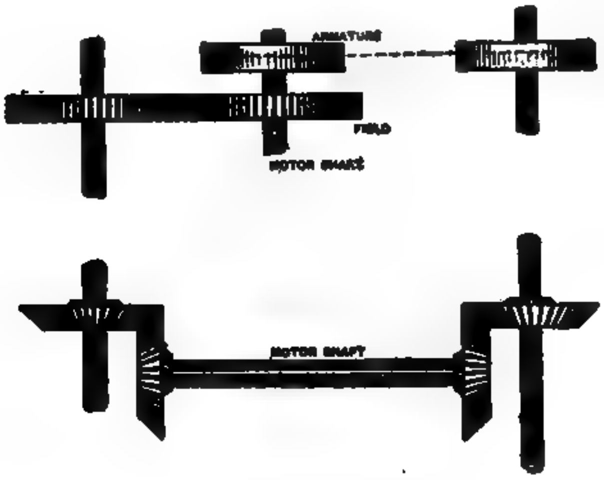


FIG. 12.—Motor Gearing.

even more satisfactorily than by the use of two independent motors, which do not always pull together with as much harmony as might be desired. There are various means by which motion might be communicated from one part of the motor to the more remote of the driven axles, two ways being shown in Fig. 12. In any case the gears employed may all be of large size, and the wear and resultant rattle, consequent upon the use of small pinions, is avoided.

FIG. 13.—Motor Gearing.

There is one other suggestion which I wish to make, and that is in regard to a system of gearing that might advantageously be applied in gearing down high-speed motors of considerable power. The proposed arrangement is shown in side elevation in Fig. 13. Only four gears are employed in obtaining any reduction from 1 to 5 to 1 to 100 or more if desired, and these gears are all spur gears of very nearly equal size; being more nearly of equal size the greater the reduction of speed. A is the high-speed (driving) shaft, B the low-speed (driven) shaft; a is a fixed gear, d the gear on the driven shaft; b and c two gears revolving together with a shaft D, which takes its bearing in the end of the piece C, which is keyed to and revolves with the driving shaft. Suppose, for simplicity, that the two gears a and b are of equal size, then it is clear that if the two gears c and d are also of equal size when the part c revolves, the gears b and c will roll around on a and d without imparting any motion to d. If, however, c and d be made to differ in size there will be a relative motion between a and d, and since a is fixed d will be driven either in the same or opposite directions as A and C revolve, according as the gear c is smaller or larger than d. As an example, suppose a and b have each 100 teeth, c 99, and d 101; then, for every revolution A, B would revolve in the same direction an interval of two teeth, or the ratio of the speed of B to that of A would be $\frac{2}{101} = \frac{1}{50}$ nearly. For a reduction of speed from 10 to 1 approximately, as ordinarily used in street car motor work, the number of teeth in c and d would be 95 and 105. By placing two more gears which have a different velocity ratio by the side of c and d, with a clutch arrangement, whereby either of the gears on the driven axle may be engaged with it, two different speeds may be provided for at very slight additional expense.

* By reducing the size of b and increasing that of c, this same arrangement would serve as a very efficient friction gearing between low-speed engines and high-speed dynamos, which could be thrown into operation or out by tightening or loosening the nuts which hold the two parts of the cones, c c, together.

EXPERIMENTS ON THE BEST SPEED FOR DYNAMO-ELECTRIC MACHINES.*

BY M. RECHNIEWSKI.

A good dynamo ought to run regularly, without sparking, should give a good efficiency and ought not to heat dangerously by running for many hours, or even for several days, if necessary. The first two conditions can be fulfilled by careful mechanical construction on the one hand and good electrical designing on the other. Of this I will not speak more for the present. The efficiency depends on a complex series of different phenomena which have been heretofore often discussed. This question of efficiency is directly connected with that of heating, of which I am going to speak more in detail. Indeed, efficiency and heating both depend on the quantity of energy transformed into heat in the interior of the machine. Heating is the foe from which designers have most to fear, and it is the thing above all others which limits performance of even the best machines. It has often happened, for example, in the laboratory of the Société pour L'Eclairage Electrique, that a dynamo designed for 14,000 watts was forced for an hour up to 22,000 watts, and the machine ran well and did not break down: but the temperature had risen at the end of an hour to 80deg. As it takes about two hours for this machine to attain its steady temperature, it was clear that this forced output could not be continued without danger. It has often been proposed to avoid this difficulty by the use of fireproof insulating material. MM. Fritsche and Pichon, in Germany, and M. Chertemps, in Paris, have employed this expedient and do not fear any temperature below 200deg. Nevertheless, it is somewhat likely that this practice will not become general. It presents too many inconveniences; beside, while it increases the output of the machine, it diminishes the efficiency. The copper increases in resistance on heating, so that the voltage in the machine varies considerably as the temperature rises. The heating reaches the commutator and brushes and renders the care of them more difficult. Fireproof insulating material takes more space than usual, and possesses less endurance from a mechanical standpoint, so that one may often lose more output by the diminution of the useful volume of copper on the armature than is gained by the possibility of running at higher temperatures. I think the maximum temperature which can safely be admitted for the armature is about 70deg., say about 40deg. to 50deg. above the temperature of the surrounding air. At this point insulating material stands well, and the effect of increased resistance of the copper is little noticeable.

The amount of heating depends on two factors—the amount of energy transformed and the cooling surface. For field magnets the solution is clear enough. About eight square centimetres of cooling surface is required per watt transformed into heat. In the case of the armature the problem is not so simple, for the quantity of heat produced depends on several variables. First, on the current in the wires; second, on Foucault currents in the same wires, in

* Paper read before the International Society of Electricians.

the core, and, in general, in all the metallic parts of the armature; third, on hysteresis of the core under the reversals of magnetisation. Cooling depends on the linear velocity and on the surface exposed. The task of the constructor is then to determine all these quantities so as to produce the maximum output without passing the safe limit of heating, say, 40deg. above the temperature of the surrounding air.

Let us consider a machine of any construction whatever. The output which can be obtained from it without heating above the prescribed limit will vary with the velocity. There is evidently but one speed for which this output is a maximum, and it is particularly interesting to determine this. Preserving a constant magnetisation, the ordinary condition in practice, power, P, furnished by a given armature, will be proportionate to its velocity, v, and to the density, δ, of the current in the wire.

$$P = \alpha\, v\, \delta.$$

The heating produced by the current is proportionate to the square of the current density. If V is the total volume of copper on the armature and ρ the specific resistance of copper, this will be

$$\rho\, V\, \delta^2.$$

This loss of energy by Foucault currents of every kind is proportionate to the square of the velocity, and can consequently be written

$$\beta\, v^2.$$

Finally, the loss by hysteresis is proportionate to the velocity. Designating by V_f, the total volume of iron in the armature, by σ, the loss of energy per cubic centimetre for a complete cycle of magnetisation, and by N, the number of reversals per second, we can write for the loss by hysteresis

$$N\, \sigma\, V_f$$

where $N = \gamma\, v$ is proportionate to the velocity. The total loss will then be

$$\Delta P = \rho\, V\, \delta^2 + \beta\, v^2 + \gamma\, \sigma\, V_f\, v.$$

The quantity of heat which the armature loses by radiation for a given difference of temperature, 40deg., for example, is a function of the form and dimensions of the surface, S_r, of the armature and of the peripheral velocity, v. When the permanent state is reached, this quantity of heat lost must be equal to the heat produced, Δ P,

$$\Delta t\, f\,(S_r\, v) = \rho\, V\, \delta^2 + \beta\, v^2 + \gamma\, \sigma\, V_f\, v.$$

It then remains to determine the velocity for the current density, δ, so that the output of the machine will be the greatest possible, while the rise in temperature must not exceed 40deg. We can represent as a function of the velocity, v, the quantity of heat which it is possible to develop in the armature without passing the temperature limit of 40deg. Let a, Fig. 1, be the curve. The quantity

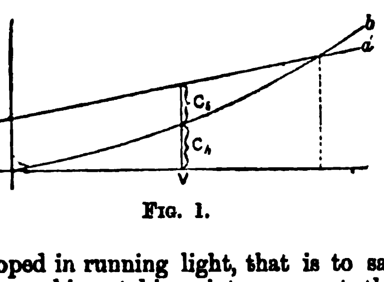


FIG. 1.

of heat developed in running light, that is to say, simply exciting the machine, taking into account the exterior current, would be represented by a short curve, b. The quantity of heat which it is permissible to develop in the wire by the discharge of current is then given for each velocity by the difference of the two ordinates. When the velocity is raised sufficiently there will be a point where the two curves intersect. At this speed hysteresis and parasitic currents alone are sufficient to raise the temperature to 50deg. At this speed, consequently, the machine cannot do any exterior work of a permanent sort. There will be, too, a velocity for which this exterior work will be a maximum. Given the two curves, a and b, one can find this velocity by calculation, or it can be found experimentally. Let V be this velocity for the machine considered, C_h, C_δ, the heats developed at this point by hysteresis and parasitic currents on the one hand and by the normal currents for the machine on the other. The dynamo is then running at what we may call its best speed. It can be easily proved that when the dimensions of the armature are increased this best rate is constant for a given peripheral velocity, V. This velocity does not depend on the form of the armature or upon its dimensions, provided that the armature in changing its dimensions changes them symmetrically.

Consider, for example, a machine of which the dimensions are n times greater than those of the machine for which we have determined the best peripheral speed, V, and let us run this large dynamo at this speed. The volume of iron involved is n^3 times greater, but the number of reversals in magnetisation will be n times smaller, consequently the heat produced by hysteresis will be n^2 times that in the smaller machine. Loss of parasitic currents increases almost in the same proportion if the machine is well constructed, for this loss depends on the peripheral velocity, the division of the materials—which is the same in the two cases—and the surface of the armature more than upon its volume. To sum up, the heat C_h developed by hysteresis and parasitic currents would be n^2 times larger; but the cooling will be also n^2 times larger, since it only depends on the surface and peripheral velocity, consequently the total quantity of heat which one can allow to be developed without danger to the armature would be n^2 times greater than before. The quantity of heat, C_δ, which can be permitted to be developed in the wire will be also n^2 times greater, which gives

$$\delta' = \frac{\delta}{\sqrt{n}} = \delta\, n^{\frac{1}{2}}.$$

The ratio of these two quantities of heat remains constant for all similar armatures which have like dimensions on condition that they are run at the same peripheral velocity, v. The power, P′, developed by the large machine will be, as can be simply calculated, $n^{\frac{3}{2}}$ greater than in the small machine, and the heating of the machine in its permanent running condition will be the same. We see, then, that this first machine gives its maximum power for a certain peripheral velocity, V. The large dynamo will furnish its greater power at the same velocity, which was the proposition laid down to be demonstrated.

Let us consider, now, more in detail the different losses of energy in the armature. The loss by the passage of the current through the wire is inevitable and can be easily calculated. The same is true of the loss of energy in hysteresis, but this is not true for the loss by Foucault currents. By means of careful construction this can be diminished very much until it is almost negligible, although the task is not always easy. The loss from this cause in the iron can be reduced to a very small quantity by sufficient care in lamination; but in machines for large output there are similar losses in the wires it they are of large size, or between the different wires of a group if they are joined in multiple arc. These losses can be reduced by composing the windings of a large number of thin wires in parallel, and twisting them together before being wound upon the armature. This arrangement, however, is objectionable from the space occupied, for less wire can be put upon the armature than if the individual wires were placed parallel to each other. Toothed armatures are not subject to this difficulty, for the teeth protect the wire placed in the interstices; in other words, all the wires placed in a given slot are submitted at the same time and not successively to the changes in magnetisation, and consequently there are no differences of potential produced between them. This constitutes a considerable advantage in using toothed armatures for large machines. The parasitic currents are inconsiderable, as we have shown by placing bars of copper in the slots and turning the armature in a magnetic field.

The following results were obtained in the laboratory of the Société pour L'Eclairage Electrique. The curves of Fig. 2 represent the losses by hysteresis, Foucault currents and friction in a machine giving 14,000 watts at 110 volts and 127 amperes at 1,250 turns per minute. Circles dotted in the centre show for each current the velocity at which the potential of 100 volts was reached. These curves are

obtained in the following way: The armature was run light as a motor for different excitation of the field magnets, and the current and voltage absorbed by the armature were noted at different speeds. The current multiplied by the voltage gives the work absorbed by the armature running empty. Plotting for each excitation of the magnets this work as ordinates and the speeds as abscissæ, we obtain the curves 1, 2, 3, and 4. In making these

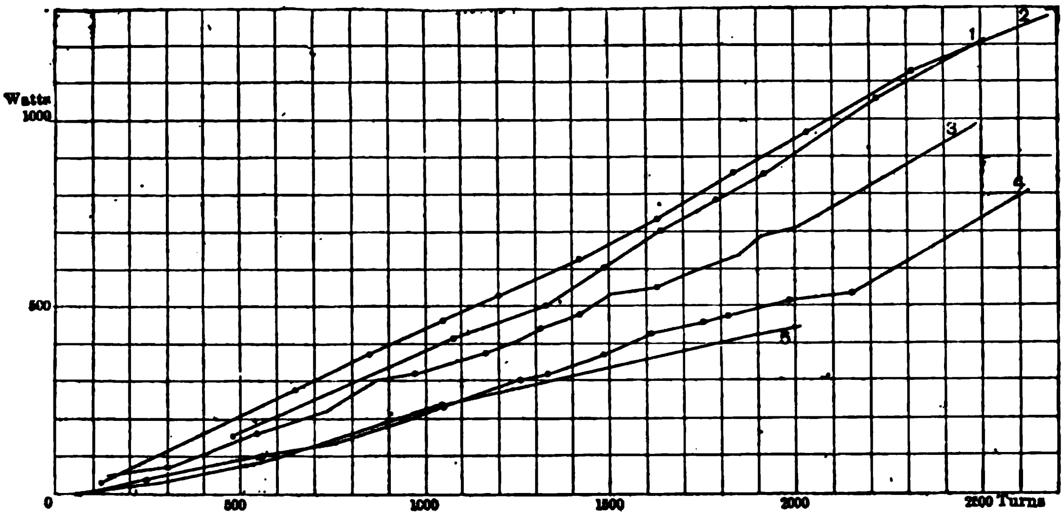


FIG. 3.—Losses in Dynamos Running Light at Various Speeds.

experiments the purpose was to determine the magnetic field and the speed which would give for a given frame, first, the best efficiency; second, the greatest output. For

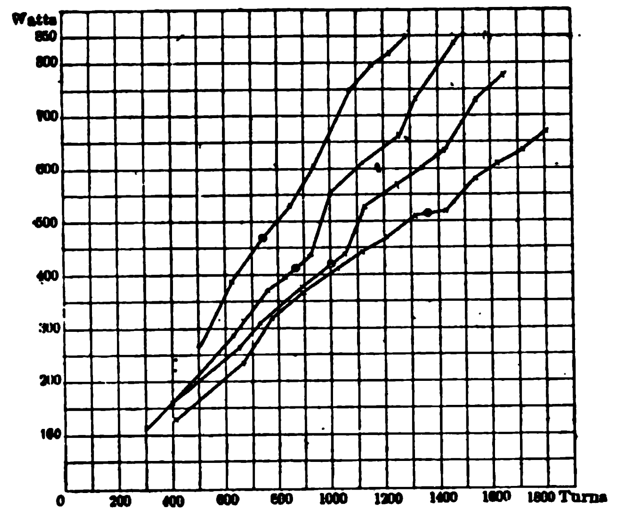


FIG. 2.—Losses in Dynamos Running Light at Various Speeds.

this purpose it is necessary to know how losses of a machine vary when either field or velocity are made to vary. Curve 1 gives losses for a field of 7,240; curve 2, 6,000; curve 3, 5,200; curve 4, 3,800; counting as the strength of the

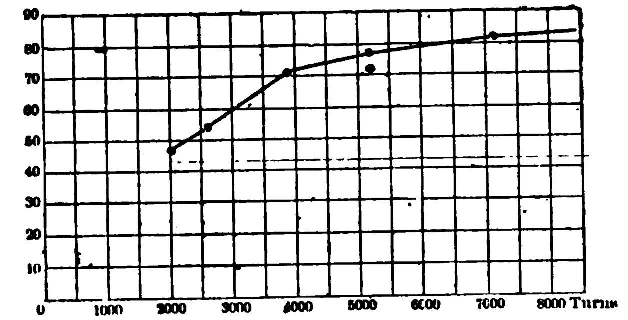


FIG. 4.—Characteristic of a 10-Kilowatt Machine.

field that developed in the pole-pieces. We see from the form of the curves that the losses increase in this machine at a rate varying nearly proportional to the velocity—that is to say, the Foucault currents are negligible. The slight curvature of the curve toward its top can be attributed to the mechanical friction of the air, which increases as the square of the velocity. Fig. 3 shows the same curves for a machine giving normally 10,000 watts at 1,400 turns, and for successive excitations of 2,000, 2,600, 3,900, 5,200, and 7,150 ampere-turns. Fig. 4 represents the characteristics of this machine. As is evident, the normal field requires an excitation of about 3,900 ampere-turns. Tables 1, 2, 3, 4 and 5 are the data from which curves of Fig. 3 were drawn. They show the voltage corresponding to each velocity and to each excitation.

TABLE I.

Magnetising force, 7,150 ...... {Current, 2·75 amperes. Number of turns, 2,600.

Current in armature.	E.M.F. at brushes.	Energy absorbed in armature.	Number of turns.
5·07	31	157·17	486
6·22	52	323·44	876
6·55	63	412·65	1,074
6·55	76	497·80	1,332
6·87	90	618·30	1,514
7·00	100	700·00	1,630
7·33	107·5	787·97	1,792
7·47	113·5	847·84	1,912
8·02	133	1,066·66	2,288
8·02	150	1,203·00	2,506

TABLE II.

Magnetising force, 5,200 ...... {Current, 2 amperes. Number of turns, 2,600.

Current in armature.	E.M.F. at brushes.	Energy absorbed in armature.	Number of turns.
3·50	7·00	24·5	116
6·87	[39·50	271·36	652
7·75	49	379·75	856
7·75	60	465	1,056
7·75	68	527	1,204
8·00	78·50	628	1,420
8·10	92	745·20	1,624
8·20	105·5	865·10	1,836
8·50	115	977·50	2,036
8·70	132	1,148·40	2,312
8·80	143	1,258·40	2,616
8·80	153	1,346·40	2,812

TABLE III.

Magnetising force, 3,900 ...... {Current, 1·5 amperes. Number of turns, 2,600.

Current in armature.	E.M.F. at brushes.	Energy absorbed in armature.	Number of turns.
3·50	8·50	29·75	120
4·14	16·50	68·31	300
5·40	30	162	544
5·60	39	218·40	740
6·20	47·50	294·50	840
6·50	50	325	972
6·50	59·50	386·75	1,168
6·55	63	412·65	1,256
6·80	66	448·80	1,310
6·80	71	482·80	1,424
7	76	532	1,500
7	78·50	549·50	1,620
7	85	595	1,704
7·30	89·5	658·35	1,852
7·30	95	693·50	1,900
7·30	98	715·40	2,010
8	125	1,000	2,474

TABLE VI.

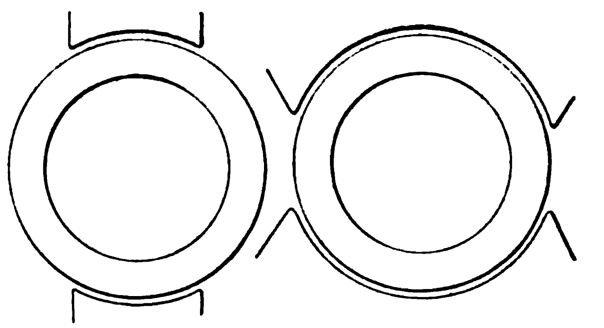
Receiving machine.				Driving machine.				Efficiency.	
E.M.F. at the terminals.	Current.	Speed.	Power furnished.	E.M.F. at the terminals.	Current.	Speed.	Power at the terminals.	Of the whole.	Of each machine.
121·6	60	1,572	7,296	101·84	53·3	1,554	5,429	0·744	0·862
119·6	60	1,534	7,176	99·5	53·3	1,524	5,292	·737	·858
119·6	60	1,534	7,196	99	53·7	1,504	5,316	·740	·860
126·5	63	1,534	7,969	103·7	54·2	1,648	5,620	·705	·839
123·6	55·7	1,610	6,884	101·8	48·7	1,580	4,955	·719	·848
123·6	52	1,610	6,427	103·2	46·3	1,574	4,778	·752	·867
123·6	50·8	1,654	6,278	104	44	1,620	4,576	·728	·853
123·6	46·3	1,654	5,722	104	40·4	1,610	4,201	·734	·857
123·6	43·4	1,654	5,364	103·7	37·4	1,600	3,878	·722	·850
123·6	40·2	1,654	4,968	103·7	33·7	1,618	3,494	·703	·838
123·6	35·0	1,678	4,326	104·6	28	1,628	2,928	·677	·822
123·6	31·4	1,678	3,881	105	24	1,662	2,520	·649	·805
123·3	27·3	1,666	3,374	105·6	20	1,624	2,112	·625	·791
123·6	24·7	1,744	3,052	106	16·7	1,650	1,770	·665	·815
123·6	10	1,758	1,236	106	...	1,732	...	·665	·815
123·6	7·2	1,758	889	...	...	1,700	...	·665	·815

I have made the same experiments with several otherl types—among these my 5,700-watt machine. The steady temperature of this class of machines is found to be 65deg. for the armature and 55deg. for the field magnets. Under these conditions the resistance of the armature at 65deg. was ·059 ohm, the resistance of the series coil ·0358 ohm, of the shunt coil and of the rheostats 61 ohms. At full load it gave 110 volts at the terminals, 51·8 amperes on the exterior circuit and on the series coils, 52·6 on the armature and 1·8 on the shunt coils. The losses by heating can then be calculated as previously and amount to 472·366 watts. The loss by hysteresis and Foucault currents at 1,600 turns and the normal field amounted to 307 watts. Total energy lost was then 779·366 watts, which gives an efficiency of 0·88. Two similar machines were then belted together and gave the results shown in Table VI., one acting as a motor and the other as a generator.

It will be seen from this table that the highest efficiency obtained was 0·867, differing, consequently, by 1·3 per cent. from the calculated efficiency. This difference is quite explicable by the difference in speed of the two machines. For example, the first machine ran at 1,610 turns, the second at 1,574. There were then 36 turns lost by slipping. This difference in speed is more than sufficient to explain the difference between the measured and calculated efficiencies. This last table is quite interesting, because it gives the efficiency at different loads. It will be noticed that the efficiency is given through quite wide limits; even running at one-third load it still remains nearly 80 per cent.

High Power Machines.—We have seen that as the dimensions of machines increase the output increases rather more rapidly than the weight. On the other hand, the diminution in labour in building does not correspond with this increase of weight, because the pieces become harder to manage, and are not as conveniently made as the parts of smaller machines. Consequently, large machines made on similar patterns with small ones should cost rather more. What, then, is the most economical construction? It is probably reached by modifying the relative dimensions of the pieces. The cooling surface must be increased by interior ventilation, or by making the armatures shorter and of larger diameter. These modifications determine a new peripheral speed somewhat higher than the original, and a rather greater current density. In other words, for each size of machine there are certain forms and dimensions which will give the best result. These very large dynamos present certain special difficulties which should be carefully noted.

Suppose that the dimensions are increased in the ratio of 1 to n to produce the same field running light, n times the original number of ampere-turns will be required on the field magnets; but meanwhile the number of ampere-turns on the armature for the same heating increases in the proportion of n^2 to 1, so that for a certain definite size it would equal the ampere-turns on field magnets, consequently sparking must ensue. The excitation of the magnets should be increased to compensate for the voltage lost by the demagnetising action of the armature. The larger the machine the more this effect will make itself felt unless the magnets both as to iron and copper are increased in size. The effect is very marked indeed in shunt-wound machines submitted to considerable variations of load. Before there is time to adjust the excitation to this variation a formidable sparking often injures the commutator. The exterior field is likely, too, to become powerful. These inconveniences increase so seriously that it seems to me almost impossible to construct bi-polar machines of very high power.



FIGS. 6 and 7.

Multipolar machines, 500 to 1,000 h.p., do not present these difficulties. From every point of view which comes under our consideration they act as a series of bi-polar machines of smaller size, joined in multiple. The number of ampere-turns in the armature is divided by the number of poles so that one can construct multipolar machines as powerful as may be desired with an armature reaction as weak as convenient. Such machines can even be constructed so as to have no lead of brushes. It is only necessary for this to construct them with a considerable number of poles so as to reduce the reaction of the armature and to force the excitation slightly. It is impossible to do this in machines with large poles wound shunt or compound. All these inconveniences of reaction of the armature come from the fact that, to avoid sparking at the brushes, we are obliged to place them in a position where the field produced by the armature is counterbalanced by the field produced by the magnets, which compels us to furnish to the magnet a number of ampere-turns greater than the maximum of those which can be produced at any time by the armature. The ampere-turns of the armature and the field magnets work then in opposition and neutralise each other. The effect is very noticeable on machines with straight pole-pieces. Fig. 6, since the ampere-turns of the armature between the pole-pieces work directly in opposition to the magnets, although under the pole-pieces they only distort the field; they would not even tend to diminish it if certain effects of saturation in the iron did not complicate the phenomena.

But it is possible to employ other methods [illegible] stopping sparking at the brushes, and in this case n[illegible] only the

ampere-turns in the armature need not necessarily be put in opposition with those of the magnets, but even may help them. Consider the arrangement of Fig. 8. N S is the principal electromagnet which we put in the interior of the ring armature. Two little electromagnets designed to stop

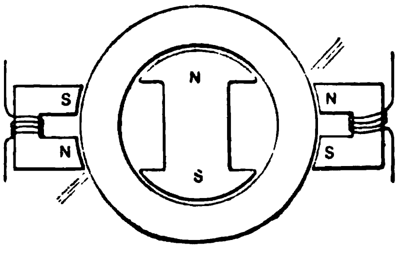


FIG. 8.

sparking are also shown. We see that in this position the ampere-turns of the armature increase or diminish the field. One could then even make a machine without wire upon the magnets. During the past winter I have made some experiments on a machine constructed on the above principle, and the results completely agree with the theory. Mr. Swinburne, one of the cleverest English electricians, has given recently the results of some other experiments for obtaining the same results.

REPORT OF THE COMMITTEE ON ELECTRICAL STANDARDS TO THE BRITISH ASSOCIATION.

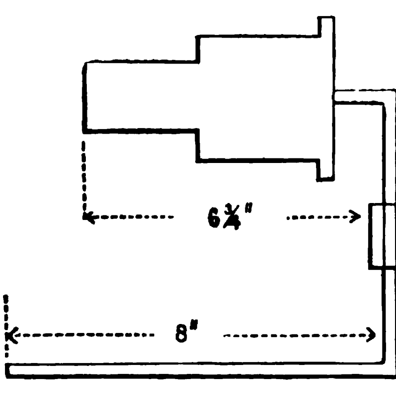
LEGAL OHMS.

The work of testing resistance coils has been combined at the Cavendish Laboratory. A table of value found for the coils is appended:

No. of coil.				Resistance in legal ohms.	Tempera-ture.
Nalder	1,577	C.L.C.	189	·99981	16·9
Nalder	1,578	C.L.C.	190	1·00089	16·9
Nalder	1,579	C.L.C.	191	1·00041	16·9
Edison-Swan	16	C.L.C.	192	·99846	13·9
Elliott	229	C.L.C.	193	1·00028	16·9
Elliott	230	C.L.C.	194	1·00021	16·9
Simmons	—	C.L.C.	195	·99992	16·8
Nalder	1,626	C L.C.	196	1·00045	15·3
Nalder	1,627	C.L.C.	197	1·00056	15·3
Nalder	1,628	C.L.C.	198	1·00058	14·8
Nalder	1,580	C.L.C.	199	1·00072	15·3

B.A. UNIT.

It would be of considerable advantage in the testing if all the coils were made of a uniform size. The original standards of the association measure 6¾in. from the bottom of the case to the underside



of the horizontal portion of the copper connecting rods, while the vertical portion of these rods is 8in. in length. These dimensions should be adopted in all coils sent to be tested; if this be done the baths, etc., made to hold the standards hold the coils equally well, and the additional convenience in testing is very great.

The original standards of the association have again been several times compared among themselves.

The results of the comparisons appear to show that while the coils, A, B, C, D, E, and Flat, have remained constant relative to each other, the three platinum silver coils, F, G, and H, have changed.

The change in F was referred to at the end of the report in 1888, and is now very large. The coil has increased in resistance by about ·0006 B.A. units; G, on the other hand, has fallen by about ·0002 B.A. units, and H by about ·0001 unit. The evidence for these various statements is given in an appendix to the report by the secretary.

It is perhaps worth remark that in each case the change either took place during the time that the coil was immersed in ice or was found to have happened when the coil was next measured after its removal from the ice.

The legal ohm coils have not varied relative to Flat.

The investigations into the resistance of copper have been continued by Mr. Fitzpatrick. The committee desire again to thank the gentlemen who have rendered him assistance in various ways.

Mr. Fitzpatrick has examined various specimens of copper supplied him as wire. He has also examined copper prepared for him as pure by Messrs. Sutton, as well as some which he prepared himself electrolytically from carefully purified copper sulphate. These last two specimens lead to practically the same value as that obtained by Matthiessen for the specific resistance of copper—viz., $1{,}767 \times 10^{-9}$ B.A. units at 18deg., the specific gravity of these specimens is about 8·90. Two wires supplied to him have, however, a distinctly lower resistance: the value for one being $1{,}731 \times 10^{-9}$ and for the other $1{,}724 \times 10^{-9}$; a difference in the one case of 2 and in the other of 2·4 per cent. The specific gravity of the first of these wires is 8·940 and of the other 8·946, and Mr. Fitzpatrick assigns the increased conductivity to increased density rather than to greater purity.

Matthiessen gives his results for the resistance of copper at 0deg. The observations were, however, made mostly at a temperature of 18deg. or 20deg., and reduced to 0deg. by the use of a temperature coefficient. So that the value at 18deg. found from that at 0deg. by the same coefficient will probably represent the result of Matthiessen's work more accurately than the one he gives himself. Various other points of importance are discussed in Mr. Fitzpatrick's appendix. He hopes to be able to give the results for some copper prepared by chemical means by Mr. Skinner and himself. He has also made a number of measurements on silver, but these are not yet complete.

Dr. Muirhead and the secretary have both been working independently at the construction and measurement of a standard air condenser.

Two such condensers have been made for the committee by the Cambridge Scientific Instrument Company, on a plan suggested by Dr. Muirhead, and mentioned in the last report. The capacity of each of these is about ·02 microfarad. Some slight alterations are required to one of these, the other is completely satisfactory. Its capacity has been repeatedly found, and remains constant to at least within one in 2,000, which is about the limit of accuracy attained. Its insulation resistance is good, the loss by leakage being about one in 1,000 of the total charge per one minute. It has been found possible to compare readily with this standard various mica condensers having capacities of 1, ·5, ·1, and ·05 microfarad. The accuracy of these determinations is about one in 2,000. A full account of the construction of the condensers, and of the method of making the various tests, is given in an appendix by the secretary, while Dr. Muirhead has contributed some notes on his own condensers and tests.

Another appendix contains an account of a very careful and interesting comparison between the standard mercury thermometers of the association and a platinum-resistance thermometer constructed by Mr. E. H. Griffiths. The resistance thermometer was graduated by means of Regnault's numbers for the vapour pressure at various temperatures between 0 and 100.

The curve of corrections obtained in this way is exactly parallel to that given by the Kew comparisons; there is throughout the range a constant difference of 0·02deg. between them. This amount is within the limits of error on the mercury thermometer.

The question of the best value to adopt for the dimensions of a mercury column having a resistance of one ohm has been raised by some members of the committee during the year. There is no doubt that the column of 106 centimetres adopted by the Paris Conference in 1884 is too short.

After a discussion of the results of the most recent observations, the following resolutions were adopted by the committee:

(1) The committee recommend for adoption as a standard of resistance sufficiently near to the absolute ohm for practical purposes the resistance of a column of mercury 106·3 cm. in length 1 square mm. in section at a temperature of 0deg. C.

(2) That for the purpose of issuing practical standards of resistance the number ·9866 be adopted as the ratio of the B.A. unit to the ohm.

Thus the new unit may be obtained from the B.A. unit by increasing it in the ratio ·9866 to unity, or, to put it differently, the specific resistance of mercury in B.A. units is taken as $·9535 \times 10^{-4}$, and the length of a column of mercury which has a resistance of one B.A. unit as 104·97 cm. The specific resistance of mercury in ohms is $·9407 \times 10^{-4}$.

In conclusion, the committee wish to ask for reappointment to enable them to continue the work of constructing and issuing standard instruments. Of the grant of £50 made at Newcastle, only £12. 17s. has been drawn. In order to check any further change in the values of the B.A. units, and to render it less necessary to employ the original standards in all the comparisons which are made, it is desirable that the committee should possess three or four copies of the B.A. unit; while to enable comparisons to be made between the new air condensers and condensers of capacity compatible with a microfarad, a resistance box going up to several hundred thousand ohms is required.

The committee are of opinion that they should be in a position to purchase these resistances; they therefore recommend that they be reappointed with a grant of £100, that Prof. Carey Foster be the chairman, and Mr. R. T. Glazebrook secretary.

THE BRITISH ASSOCIATION AT LEEDS.

PRESIDENTIAL ADDRESS BY SIR FREDK. AUGUSTUS ABEL, C.B., D.C.L., D.Sc., F.R.S., &c.

(*Concluded from page 277.*)

Another most remarkable feature connected with the development of the petroleum industry is presented by the utilisation, within the last few years, of the vast supplies of natural inflammable gas furnished by the oil fields.

In America this remarkable gas supply was for a long time only used locally, but before the close of 1885 its conveyance to a distance by pipes, for illuminating and heating purposes, had assumed large proportions, one of the companies in Pittsburgh having alone laid 335 miles of pipes of various sizes, through which gas was supplied equivalent in heating value to 3,650,000 tons of coal per annum. Since then the consumption in and around Pittsburgh has probably been at least tripled. At the close of 1886 six different companies were conveying natural gas by pipes to Pittsburgh from 107 wells; 500 miles of pipe, ranging in diameter from 30in. to 3in., were used by these companies, 232 miles of which were laid within Pittsburgh itself. The Philadelphia Company, the most important of these associations, then owned the gas supply from 54,000 acres of land situated on all the anticlinals around Pittsburgh, but drew its supplies only from Tarentum and the Murraysville field. It supplied, in 1886, 470 factories and about 5,000 dwellings within the city, besides many factories and dwellings in Alleghany, and in numerous neighbouring villages. The average gas pressure at the wells, when the escape is shut off, is about 500lb. per square inch, and in the case of new wells this pressure is very greatly exceeded. In order to minimise the danger from leakage, the gas pressure in the city is reduced to a maximum of 13lb., and is regulated by valves at a number of stations under the control of a central station. The usual pressure in the larger lines is from 6lb. to 8lb., while in the low-pressure lines it does not exceed 4oz. to 5oz.

The effect of the change from coal gas to natural gas upon the atmosphere over Pittsburgh has been most marked; formerly the sky was constantly obscured by a canopy of dense smoke; now the atmosphere is clear, and even white paint may with impunity be employed for the house fronts.

The very rapid development of the employment of natural gas is not confined to the neighbourhood of Pittsburgh; it is used for heating purposes in the cities of Buffalo, Erie, Jamestown, Warren, Olean, Bradford, Oil City, Titusville, Meadville, Youngstown, and perhaps twenty more towns and villages in Pennsylvania, and North-Western New York. In North-Western Ohio, the cities of Toledo and Sandusky, the towns of Findlay, Lima, Tiffin, Fostoria, and others in that section are also supplied with natural gas; a pipe line has, moreover, been recently laid to Detroit, Mich., and it is estimated that in these localities 36,131,669,000 cubic feet of the gas were consumed during last year, displacing 1,802,500 tons of coal. To the south-west of Pittsburgh there are many smaller places which consume natural gas; it also occurs in considerable quantity, and is being utilised, in Indiana (whence an account has recently reached us of a terrific subterranean explosion of the gas); and it is at the present time contemplated to carry a natural gas supply to Chicago.

The utilisation of the natural gas of the Russian oil fields, although of very ancient date, has hitherto not been extensive, neither does the magnitude of the supply appear to bear comparison with that of the Pennsylvanian district.

A form of gaseous fuel which has long been known to technical chemists and metallurgists, but which has of late attracted considerable attention, especially in connection with the recent interesting work relating to its applications pursued by Mr. Samson Fox, of Leeds, has become within the last four years, a competitor in the United States, both of the natural gas of Pennsylvania and of coal-gas. Since Felix Fontana first produced so-called water-gas in 1780 by passing vapour of water over highly-heated fuel, many methods, differing chiefly in small details, have been proposed for carrying out the operation, with a view to the ready and cheap production of the resulting mixture of hydrogen and carbonic oxide, and numerous technical applications of water-gas have been suggested from time to time, with no very important results, excepting as regards its use for lighting purposes. Being of itself non-luminous, its utilisation in this direction is accomplished, either by mixing it with a highly-luminous gas, or by causing a hydrocarbon vapour to be diffused through it, or the non-luminous flame, produced by burning it in the air, is made to raise to incandescence some suitably-prepared solid substance, such as magnesia, lime, a zirconium salt, or platinum, whereby bright light is emitted. The objection to its employment as an illuminant for use in buildings, to which great weight is attached by us, and rightly, as sad experience has shown—viz., that, as it consists, to the extent of about one-half its volume, of the highly-poisonous gas carbonic oxide, the atmosphere in a confined space may be rendered irrespirable by a small accidental contamination with water-gas, by leakage or otherwise, not detectable by any odour—appears to constitute no great impediment to its employment in the United States, as it is now manufactured for illuminating and heating purposes by a large proportion of their gas works, being in some places employed in admixture with a highly-luminous coal-gas, in others rendered luminous by the alternative methods mentioned. It is stated that about three-fourths of the illuminating gas now supplied to the cities of New York, Brooklyn, Philadelphia, Jersey, St. Paul, and Minneapolis, is carburetted water-gas; in Chicago the entire supply now consists of this gas, and Boston will also soon be supplied exclusively with it. The use of water-gas for metallurgic work does not appear to be contemplated in the United States, but it is especially to such applications of the gas that much attention has been devoted here in Leeds; and although some eminent experts are sceptical regarding the attainment of advantages, especially from an economical point of view, by the employment of this form of gaseous fuel, especially after practical experience in the same direction acquired in Germany, the technical world must feel grateful to Mr. Fox for his work in this direction, affording, as it does, an interesting illustration of the qualities of perseverance and energy which, when combined with sound knowledge, often achieve success in directions that have long appeared most unpromising—qualities which have been characteristic of many pioneers in industrial progress in this country.

Leeds has been especially fortunate in the possession of such pioneers who, when competition brought about great changes in the particular trade through which, for many generations, this city chiefly enjoyed prosperity and high renown, developed its power and resources in new directions, from which success soon flowed in continually increasing measure. The rapid rise of Leeds to its present high position in industrial prosperity and national importance most probably dates from the period when its chief staple industry began to experience serious rivalry, in its own peculiar achievements, on the part of other districts of the kingdom and of other countries. From early days a flourishing centre of one of the provinces of Great Britain most richly endowed with some of Nature's best treasures, Leeds could scarcely have failed, through the energy, acute intelligence, and powerful self-reliance especially characteristic of the men of Yorkshire, to rapidly acquire fresh renown in connection with industries which either were new to the town and district, or had been pursued in comparatively modest fashion, and which have combined to place the Leeds of to-day upon a higher pinnacle of commercial prosperity, power, and influence than her patriotic citizens of old could ever have dreamt of.

An examination into the present educational resources of Leeds places beyond any doubt the fact that her present prosperity in commerce and industries is in no small degree ascribable to the paramount importance long since attached here to the liberal provision of facilities for the diffusion of knowledge among the artisan and industrial classes, and especially for the acquisition of a sound acquaintance with the principles of the sciences and their applications to technical purposes, with particular reference to the prominent local industries, by all grades of those who pursue or intend to pursue them. There is, probably, no town in the kingdom more amply provided with efficient elementary and advanced schools for both sexes, while the special requirements of the artisan are efficiently met by the prosperous School of Science and Technology. The resources of the Yorkshire College provide, in addition, a combination of thorough scientific education with really practical training in the more important local industries; indeed, during the 16 years of its continually-progressive work, this institution has acquired so widespread a reputation that students come from abroad to reap the advantages afforded by the unrivalled textile and dyeing departments of the Leeds College. The keen competition now existing between these departments and the corresponding branches of the much younger but most vigorous sister college of Bradford, can only conduce to the further development of both, and to their thorough maintenance up to the requirements of the day.

The very important pecuniary aid afforded to these establishments, and to a number of other technical schools in Yorkshire, by one of the most important of the ancient companies of the City of London, the Clothworkers, afford an interesting illustration of the good work in the cause of education performed by those guilds and, especially of late years, by means of their flourishing institute for the advancement of technical education which, through its two great instructional establishments in London, and through the operation of its system of examinations throughout the country, extending now even to the colonies, has afforded very important aid towards eradicating the one great blot upon our national educational organisation. To have been first in the field in practically developing a far-reaching scheme for the advancement of technical education in this country must continue to be a source of pride to the City of London and its ancient guilds in time to come, when the operation of efficient legislation, supported and extendend by patriotic munificence and by the hearty co-operation of associations of earnest and competent workers in the cause, shall have placed the machinery and resources for the technical instruction of the people upon a footing commensurate with our position among nations.

The remarkable address delivered by Owen here in 1858, wherein the condition, at that time, of those branches of natural science which he had made particularly his own was most comprehensively reviewed, included some especially interesting observations on the importance to the cultivation and progress of the natural sciences, and to the advancement of education of the masses in this country, of providing adequate space and resources for the proper development of our National Museum of Natural History; and it cannot but be a source of great satisfaction and pride to him to have lived to witness the thoroughly successful realisation of the objects of his own indefatigable strivings and powerful advocacy in that direction. Comprehensive as were the views adopted by Owen regarding the scope and possible extension of that museum, it may, however, be doubted whether they ever embraced so extensive a field as was presented for our contemplation by his successor last year, when he told us that a natural history museum should, in its widest and truest sense, represent, so far as they can be illustrated by museum specimens, all the sciences which deal with natural phenomena, and that the difficulties of fitly illustrating

United States has been such that it is a little surprising that designs for satisfactory conduit systems have not received greater attention for use in the crowded towns. This seems to be now the case, however, if we may judge from the fact announced that the Thomson-Houston Company have just laid down an experimental conduit line at their works at Lynn.

London County Council.—The sanction of the London County Council has been given to the work of laying mains in various localities by the following companies: The Metropolitan Electric Supply Company, Notting Hill Electric Lighting Company, the London Electric Supply Corporation, Kensington and Knightsbridge Electric Lighting Company, Chelsea Electricity Supply Company, the Westminster Electric Supply Corporation, and the Electricity Supply Corporation.

Reading.—Before the Reading Town Council the draft agreement with the Laing, Wharton, and Down Construction Syndicate was discussed, with special reference to arbitration as to purchase at the end of seven years, which, the Mayor said, was a very small matter; and therefore they might assume that a license would be granted to the company for seven years, and at the end of that time the Council would be in a position to apply for an order to take over the undertaking if they saw fit to do so.

Heckmondwike.—At the Heckmondwike (Yorkshire) Board of Works it was proposed to use the 12-h.p. engine of the destructor works, where refuse was burnt, with the addition of a little other fuel, to raise sufficient steam for the purpose of driving a dynamo to try the experiment of lighting by electricity. It was proposed to light the market place and any tradesmen who required the light. The Board now pay the gas company £92 for lighting the market, and £269 for lighting the streets. A committee was appointed to enquire into the matter and report.

Bishop Stortford.—The clerk to the Bishop Stortford Local Board at the last meeting reported on the draft agreement with the electric light company, and recommended that three or four years should be allowed the company to carry out the works. He also thought the company should be called upon to bear the expense incurred by the Board in the matter. After some discussion, the resolution passed in August to the effect that the draft agreement be adopted, subject to modifications, was rescinded, and the application will be discussed a month hence.

Electric Shadow Wall Papers.—The electric light is being turned to very artistic use by a prominent wall paper manufacturer of New York. The dark, clear-cut shadows caused by the play of the electric light among the foliage of trees have often been remarked, and the gentleman in question has been for some time making, by means of photography, a series of records of these beautiful effects, which he intends to use in connection with his business. This collection is a valuable one, and some of the designs which have already been made from it are said to be of exceptional merit.

Gordon Electric Railway.—The trials of the Gordon electric closed conduit line are, we understand, progressing very satisfactorily. A length of line has been laid down and fitted in Messrs. Merryweather's works at Greenwich-road, and a car will be shown running very shortly. The distributing boxes have been greatly reduced in cost of manufacture; these are to be placed every 70 or 80 yards, and the cost of the line equipment is estimated at £1,200 per mile. The distributors are placed in waterproof boxes, so made that a fire hose can be actually played on them without hurting the electrical arrangements inside.

Certificates.—As the result of examinations recently held at the School of Electrical Engineering and Submarine Telegraphy, Princes-street, Hanover-square, we are informed that the following gentlemen have now obtained the vellum certificate of the school: (a) In electric lighting and power transmission—Messrs. Claypoole, Garrè, Gillies, Lawrence, Phillips, Roussel, and Waring; the examinations were conducted by Mr. Gisbert Kapp, and included a *vivâ voce* and practical examination. (b) In telegraphy and telephony—Mr. Lawrence (above-named) and Mr. Salmony; this examination was conducted by Mr. H. R. Kempe.

Mexbro'.—If enterprising electrical engineers require a target for their fires, Mexbro', in Yorkshire, would seem to be a suitable one. The gas supply, even though the price is 3s. 6d. per 1,000 cubic feet, has been reported before the Local Board as extremely defective, so much so that local tradesmen have had to light candles in their shop windows. The gas company were objected to as monopolists who would listen to no reason. The chairman said the gas was not only bad, but short in quantity, and excessive in price. Eventually the Lighting Committee were instructed to make enquiries into the whole subject of lighting, and to report to the Board at a future date.

Berlin.—The proposed electric lighting of the Grünewald colony has not met with the approval of the Board of Works, and therefore will not be carried out. According to *L'Electricien*, the application of electric lighting in Berlin shows the following increase: In 1888 540 public arc lamps and 1,709 private ones; in 1889 826 public arc lamps and 2,976 private ones; total, in 1889, 687 installations, with 3,622 arc lamps. In 1888 22,536 private glow lamps, and 23,016 public ones; in 1889 31,399 private glow lamps, and 3,147 public ones; total, in 1889, 3,622 arc lamps, and 62,816 glow lamps, besides 208 arc lamps in Leipzigerstrasse and Unter den Linden.

A New Mechanical Movement.—New mechanical movements are not often brought forward, but one which may possibly be of use for the gearing of dynamos, for the changing of reciprocating into rotary motion, is described in the *Scientific American* for Sept. 20, the invention of Mr. James Hayton, of Utah. On the rotary shaft is a cogwheel, or, rather, half a cogwheel, gearing, in the first half revolution to the cogs at the top of a sliding piece, and in the second half to the teeth at the bottom, the result being that a backward and forward movement of the sliding piece rotates the shaft. The device avoids all dead centres, and is designed to transmit power, without undue friction or lost motion.

A Radiometer Photometer. — The well-known radiometer of Mr. Crookes has been adapted as a photometer by MM. Seguy and Verschaffel. The rotating disc is not pivoted, as in the Crookes apparatus, but suspended by a silk fibre and fitted with a scale and needle, after the manner of Coulomb's torsion balance. A glass containing a solution of alum is placed between the light to be measured and the rotating disc, so as to cut off the heat rays. The light rays in falling on the disc cause it to turn round through a certain angle depending on their intensity. Thus one light can be measured after another. The apparatus is stated to be so sensitive as to indicate the one-hundredth of a standard candle.

Frankfort Exhibition.—Great preparations are being made to make the forthcoming electrical exhibition at Frankfort a success. Among the many different and attractive features to increase the public interest in electrotechnics, it is also intended to connect the exhibition by telephone with the concert hall Palmengarten, the Frankfort Opera House, both with a number of ordinary telephones, and with large loud-speaking instruments for a larger audience. Several apparatus, with penny-in-the-slot mechanism, will be in connection with the watering places near Frankfort, the Court Theatre at Mannheim, and the opera of Munich, if the Imperial line between these two towns has been completed.

The Ideal Motor.—Mr. J. W. McNamara, president of the Albany Railroad Company, speaking before a meeting of the New York Street Railway Association, expresses the feelings of all tramway directors when he says: The ideal motor is one which is independent of every other motor or other engine, and contains everything necessary to make it go. This motor exists and seems to work fairly well on grades of not more than 5 per cent.; but that it is capable of doing the work now being done by motors using the overhead system is still problematical. However, as we have already witnessed such wonders in propelling cars by electricity, may we not hope for a storage battery electric car which shall be equal to any now in use?

Cardiff.—At the monthly meeting of the Cardiff Ratepayers' Association, held last Friday, the following resolution was passed: "That the Town Council be respectfully requested to push forward with all possible speed their application for a provisional order for the electric lighting, so that the ratepayers who so desire may have the opportunity of using the electric light instead of gas, the gas company having taken advantage of the withdrawal of the Brush Light Company to again increase the price of gas, making 6d. per thousand within about 12 months, though the price of cannel coal is no higher than it was a year ago." In view of the British Association visit next year, also, a hope was expressed that electric lighting would again be available.

Carbon Brushes for Dynamos.—The use of blocks of squared carbon as brushes for dynamos and motors, instead of copper strip or wire, has achieved a great extension in American practice, but yet there are certain objections to its use, chiefly want of lubricating power and smoothness. Mr. Daft, of electric motor fame, seeks to obviate any disadvantages that may show in this direction by an admixture of powdered blacklead. He pierces the carbon block with small holes, and fills these with the blacklead, thus obtaining smoothness desired. By adding 1 or 2 per cent. of talc to the graphite, the "brushes" run absolutely silently. In view of the promised extension of electric motors for traction work in this country, it will be worth while for our manufacturers to investigate this improvement.

Bournemouth.—An application from the Brush Electrical Engineering Company, Limited, for the consent of the Council to an application to the Board of Trade for a provisional order authorising the company to supply electrical energy within the borough, was considered at the last meeting of the Poole (Bournemouth) Town Council. The town clerk said that application had been previously granted, but it had not come before Parliament, and consent was required again. Councillor Walmsley said that granting such a consent was a most serious matter. They knew what difficulty had been caused when the Poole Electric Light Company wished to put up their standards in the High-street. He moved that the matter go before the Streets and Highways Committee. This motion having been seconded by Councillor Yeatman, was carried.

Weems Electric Passenger Express.—Mr. David Weems, of Laurel, Baltimore, who has made his name already famous by the active promulgation of a scheme for sending electric mail carriages at 200 miles an hour, has already, some months ago, achieved 180 miles an hour on an experimental track with small cars. Not content with this, he is anxious to apply the system to passengers, and for this he promises a speed of 120 miles an hour. In the inventor's experimental track his expectations have been almost realised, and it is stated that an actual line is to be at once commenced. The electric train is to be of 700 h.p. and 20 tons weight, drawing two closed-in cars of the same cigar-shaped form as the mail cars already tested. An electric installation will be erected every 50 miles for the supply of electricity to the motor on the cars, and the circuit will be a metallic one, complete for lead and return. Mr. Weems' latest plans approximate much more nearly to that of the ordinary railway, so that, if successful, these lines might be used with but the minimum of alteration.

Stockport.—At the Stockport Council a resolution was brought forward to promote a provisional order for electric lighting in the borough. Alderman McClure explained that they were compelled to make this application. During the absence of Mr. Williamson (who has had the matter in hand) from the Council, two companies had applied for powers to light Stockport with the electric light. The Corporation, however, were opposed to any company coming to Stockport, and thought if the electric light was to be introduced in Stockport that the Corporation should have the power. The consequence was that they could not now remain still, for if they did not move Government would permit outsiders to come to Stockport, and give them powers to light the borough with electric light. The resolution was passed. The appointment of Mr. J. Shoolbred, 1, Victoria-street, Westminster, as electrical engineer to the Corporation, was then carried. Mr. Shoolbred had already been appointed by the Finance Committee for the purpose of drawing up the formal application, and the Council confirmed the appointment.

Accumulator Cars for Glasgow.—On Monday, September 29, a deputation from the Glasgow Corporation, consisting of Bailie Paton (convenor of general committee), Bailie Wallace (sub-convenor of general committee), Bailie McFarlane, John Ure (Dean of Guild and ex-Lord Provost), Councillor Colquhoun, and Mr. David Rankine (engineer, Glasgow Corporation tramways), visited the General Electric Power and Traction Company's electric cars and installation on the Barking-road section of the North Metropolitan Tramways Company's system. The deputation were met by Messrs. Fuller and Macpherson, directors of the General Electric Power and Traction Company, and by several of its leading officials. Having made a minute inspection of the many points of interest in the working of the cars, the Corporation authorities expressed themselves as greatly pleased with all they had seen. The reason of the visit was that the Corporation have the idea in view to take into their own hands, at the expiration of the present concession, the entire Glasgow tramways service, and equipping the same with accumulator cars. On the following day the deputa-

tion visited the installation of the Central Birmingham Tramways Company at Bristol-road and Bournbrook, Birmingham.

Exeter.—The Town Council of Exeter are exercised over the question of private *versus* public control of electric lighting. There is an active electric light company at work at Exeter, and at the same time the great desire to avoid undue fleecing of the public by monopolists, which has been such a prominent feature in dealing with electric lighting enterprises, has led the Council to consider whether they should not themselves apply for a provisional order. After much debate, however, at the last meeting of the Council, an amendment was passed disapproving of the recommendation of the committee that the Corporation should refuse consent to the application of the electric light company for a provisional order, and themselves take steps to seek these powers. The matter is, therefore, not finally settled. There is a strong desire on the part of the Council not to interfere unreasonably with the work already done, the results of which the tradespeople are already enjoying. At the same time no monopoly will be tolerated, and it is to be hoped that the committee to which the matter has been again referred will be able to arrive at a suitable arrangement with the directors of the present company to safeguard the interests of the ratepayers and consumers.

Jarman's Accumulator.—Mr. Jarman, whose electric storage car we describe in this number, is intending to bring out a new accumulator. The active material is made of a mixture of hyposulphide of lead, acetate of lead, and a small quantity of litharge. This is cast in blocks and cut by a saw into squares. The carrier is made of an aluminium-lead alloy, cast round sets of suitably arranged blocks of the active material. This accumulator, he thinks, will be able to be made at half the cost of the present cells. The solution for the accumulator is an acid solution of alum—the double sulphide of alumina and potash. One of the great disadvantages also of the present type of the cells is the frequent burning out of the connecting lugs. Mr. Jarman has perfected a connection which will not burn out. For this he takes a thick solid piece of copper rod, tinned on the exterior and tapped at both ends. This, when the ends are bent up, is cast round with lead and thoroughly embedded therein. The two ends form a double contact, on which nuts can be screwed down on the connecting piece with lead washer so as to be secure even if one end fails. If there is no deteriorating action of the copper found in practice, this ought to be a considerable improvement in detail, as a current of even several hundred amperes would not then destroy the lead lugs, as now not unfrequently is the case.

The Public Lighting of Lewes.—For some time past there has been a strong feeling of dissatisfaction at the quality and price of the gas supplied to the public lamps at Lewes; and the discontent found expression last week at a meeting of ratepayers specially convened by the Mayor (Mr. Alderman White), and held under his presidency in the Corn Exchange. There were about 500 persons present. The principal speaker was Mr. Alderman Farncombe, who laid before the meeting four schemes in detail for their consideration. The first was that the Corporation should take over the lighting plant and manage it themselves, paying for the gas consumed as under the present contract with the gas company. This scheme, with gas at 3s. 6d. per 1,000 cubic feet, would entail an outlay of £900 per annum, as compared with £800 now paid. The next proposition was that the Corporation should make their own gas; and it was estimated that this would cost £1,000 per annum. Then came a scheme of electric lighting, also put at £1,000. Lastly, water-gas was suggested at a cost of £810 or £1,070, according as lamps of 16 or 32 c.p. were used. After much talk, these four proposals were narrowed down to two—either to come to some different arrangement with the gas company, whereby the Corporation could put up their own lamp-posts and take a supply of gas from the company, or adopt the electric light. Mr. De Castro explained to the meeting the proposals of the Gulcher Company. Eventually it was decided to adjourn the meeting for a fortnight, to give the ratepayers time to study the question.

Electric Fog Signalling.—Our attention has been called to an ingenious and simple method of electric signalling for railways, which, it is hoped, will eventually entirely do away with the extraordinary expense and vexatious delays now too often experienced in cases of fogs on railway lines. The system is the invention of Mr. W. Andrews, who has had large practical experience in railway work, assisted in the electrical part of the invention by Mr. Arthur F. Guy. It consists, in effect, of a means of working a miniature semaphore on the engine itself, while yet some distance in front of the signal, that is, at such distance as a fog would obscure the signal or signal lamp. The driver has thus on his own engine an effective means of knowing whether the signal is for or against him some time before he arrives at the signal. This is done by a length of iron contact rail, mounted on earthenware insulating chairs a short space outside one of the rails, and contact is made to this by a brush on the footplate of the engine. On the engine is a miniature semaphore arm, working electrically, its normal position being sloping. When a current is sent one way the arm is put at right angles, indicating danger; when the current is sent in the other direction the arm is drawn down, showing line clear. Contacts in the signal-box are so arranged that the current is sent or reversed by the moving over of the signal lever. The system is being tried on one of the great railway lines, and is proving so far very successful; and the insulation found on this arrangement, even in wet weather, is wonderfully effective. An inspection by prominent railway officials is expected to take place shortly.

Electric Communication between Ships at Sea. The great need of all navies, says Lieut. Fiske, in his paper on "Electricity in Warfare," is a quicker and more trustworthy means of communication between ships at sea. Doubtless, most persons know that many experiments have been looking to the establishment of a means of communication by electricity. Two general lines of experiment have been followed. In one, sound vibrations are set in motion in the water, and are received on a diaphragm, usually on the under-water side of a ship; this diaphragm corresponding to a telephone transmitter, the receiver being in the pilot-house, or other convenient place. The other line contemplates sending electric signals through the air or the water, the receiver being usually a telephone receiver. During about two years, a great many experiments were made at the New York Navy Yard in the latter line, signalling both through the air and through the water. These experiments were on a pretty large scale. A large dynamo was used as a source of power, and in one case the U.S. s. "Atlanta" was converted into the largest electromagnet known, being wrapped with heavy wire, through which the dynamo current was sent, while the iron tug "Nina," 150ft. long, was made a receiver, she

THE LINEFF ELECTRIC TRAMWAY.*

BY GISBERT KAPP, M.I.E.E.

Engineers and tramway managers, not less than the travelling public, are agreed as to the desirability of replacing animal by some sort of mechanical traction, and electrical engineers in particular are convinced that of all methods of applying mechanical power that involving the use of electromotors is the most convenient for the ordinary type of tramline. On lines with exceptionally steep gradients the cable has the advantage over the steam locomotive and electromotor that the weight of the car to be hauled up the grade is a minimum; but on lines which are not too steep to be worked by steam or horses this advantage is on long lines more than counterbalanced by the waste of power involved in keeping the cable itself in motion, and it is in these cases which form the majority that the electromotor has the most promising field of application. It may be asked how it comes that with all these circumstances in its favour electric traction on tramways has made in this country so little progress. We have cheap coal, good steam engines, excellent dynamos, and thoroughly reliable and efficient electromotors. The transmission of power from the motor spindle to the axle of the car, although not so easy a problem as it might perhaps appear at first sight, does not present any insuperable difficulties, and has, in fact, been very satisfactorily solved by more than one engineer. The application of electricity to traction should therefore be an easy matter. Yet progress is slow. The explanation appears to be that although the generation of the electric current taken by itself is easy enough, and the conversion of this current into mechanical power taken by itself is easy enough, the connecting link between the two processes—namely, the conveyance of the current from the dynamo at the tramway depot to the car on the line—is a matter of some difficulty, and as yet we have no system of conveyance which may be considered as satisfactory in every respect. It is in this direction that inventors should work. There is very little need for improved dynamos, motors, switches, or other gear; all these appliances, though not absolutely perfect, are quite good enough for practical work. There is, however, great need for improved methods of conveying the electric current to the car in a manner which shall at once be economical, certain, free from danger to persons and animals, offer no obstruction to the general traffic in the streets, and be acceptable on æsthetic grounds. All these conditions except the first are fulfilled in those systems where a storage battery is used for conveying the current from the dynamo at the depot to the motor on the car; but unfortunately the first condition is too important to be neglected, since the fundamental reason for substituting mechanical for horse traction is not a humanitarian or scientific one, but the aim to save a penny or two per car mile, and thus increase the financial prosperity of the company. I do not say that such a saving may not be effected by the use of battery cars; but I say that up to the present we have no practical proof that such cars are more economical to work than horse cars; and I maintain that whatever saving may result from the adoption of batteries, a greater saving under the same circumstances must result from direct working; that is, working under some system of conveying the current direct from the dynamo to the motor by means of a conductor. On the other hand, there may be reasons for preferring the storage car, notwithstanding its lower efficiency; but I do not propose to enter into this subject, as it can only be satisfactorily discussed with reference to the local conditions in each particular case. My object is to bring before you a new system of direct supply for tramcars, which has recently come under my notice, and which seems to fulfil all the conditions stated above.

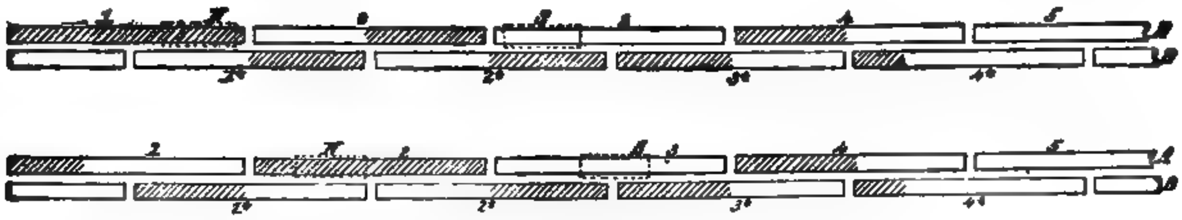
When we have to convey current to the car by means of a conductor, this conductor must run along the line either above or below ground. In the former case it may be a wire suspended along poles, or a rail resting on insulating supports close to the ground, or it may be formed by the tram rails themselves. All these arrangements have been tried, but it is needless to say that they are inadmissible for urban and suburban lines in this country. With such lines the first condition must necessarily be to place the conductor underground. As usually carried out this system involves the adoption of a slot in the road through which passes a slipper or contact shoe attached to the car, and which establishes electrical connection between the conductor underground and the motor on the car. The system is, as experience shows, practically workable; though the slot, which must admit dirt and moisture into the underground channel and may to a certain extent inconvenience other traffic, is a disadvantage. This disadvantage may perhaps not be very great considered from a purely technical point of view, but such as it is it has to be taken into account. If we consider the question from the point of view which will naturally be taken by the local authorities and the public whom they represent, we shall come to the conclusion that the slot is a great disadvantage to the general traffic, and that its abolition is highly desirable. How to abolish the slot and yet retain electrical connection between the underground conductor and the motor on the car is the problem which has been solved in the system of electric tramway I am about to describe.

The conductor consists of bare copper strip or cable, and of iron strip. The latter is galvanised so as to protect it from rusting. It lies on the copper conductor, and both are enclosed in a sealed channel formed of asphalte. The copper conductor rests upon the bottom of a trough made of a succession of glazed tiles, and the cover to this trough is formed by the lower flanges of iron rails arranged in short sections so as to be insulated from each other. The head of one rail reaches up to the surface of the road; the head of the other is cut off, and this rail is, therefore, completely buried in the asphalte. The surface rail, which may be arranged alongside one of the ordinary tram rails, or in the centre of the track, is in electric and magnetic contact with an electromagnet carried under the car. This magnet runs upon the surface rail on wheels, which form its north and south poles. The distance of the wheels is greater than the length of a section of insulated rail, so that successive sections become oppositely magnetised. This causes the iron strip immediately below the magnetised region to be attracted upwards and thus come into contact for a length of several feet with the under side of the two sectional rails. At the same time the iron strip to both sides of this region remains in contact with the copper conductor, and forms thus an electrical connecting link between the copper conductor and a few sections of insulated rail under the car. The current passes from the surface rail through the body of the electromagnet (which is insulated from the body of the car) into the motor, and finally into the ordinary tram rails and earth in the usual manner. The electromagnet is energised by a shunt current obtained from the main conductor, but to provide for the possibility of dropping the strip from some unforeseen cause, there is placed on the electromagnet a third thick wire coil, which can at all times be energised by two storage cells carried on the car, and thus the strip can be picked up and the main circuit again established if it should have been accidentally interrupted. I may, however, at once state that during some tests which I made on an experimental line of this kind, and which lasted over several days, there has been no need for the picking-up battery, as the current was never lost. I shall say a few words about the results of these tests presently; but before entering upon the practical results I would draw your attention to a question of both practical and theoretical importance—namely, the way in which Mr. Lineff makes use of magnetic lines of force to effect the attraction of the iron strip. It might, perhaps, be thought that the most direct and therefore the best way of utilising the lines of force would be by one single line of sectional rail through which there would be longitudinal magnetic flux corresponding with the fore and aft position of the poles and attraction of the strip at every gap between two sections. Experiment has, however, shown that this apparently direct way is by no means the best way, and that far more satisfactory results can be obtained by arranging a more roundabout course for the lines of force. This is attained by the employment of the subsidiary or buried rail, the gaps in which do not exactly correspond with those in the main or surface rail, but are

* Paper read before the British Association.

shifted forward by a certain amount. In consequence of this arrangement, the buried rail acts as a kind of magnetic bridge to successive portions of the surface rail, and this action takes place in two ways, one direct and the other indirect. The direct way is longitudinal, and does not affect the strip at all. The indirect way is both longitudinal and transverse, the latter passing several times through the strip. The buried rail is a rather imperfect bridge to the lines of force traversing it longitudinally, because its magnetic resistance in that direction is great, but this rail forms a very efficient bridge for lines passing through it transversely, owing to its lower magnetic resistance in that direction, which includes the strip. This flow of magnetic force transversely is, therefore, that which effects the attraction of the strip, and may be represented as a series of magnetic stitches passing to and fro between the two sets of rails and the strip.

This action will be understood by reference to the diagrams 1 and 2, which represent the magnetic condition of the rails for two positions of the electromagnet. North polarity is indicated by shading. A represents the surface rail, and B the buried rail. The energy provided to attract the strip is only 180 watts, or equivalent to that consumed by three glow lamps, and this I have found



FIGS. 1 AND 2.—Magnetic Condition of Rails—Lineff System.

FIG. 3.—Lineff Closed Conduit—Section.

FIG. 4.—Lineff Closed Conduit—Plan.

FIG. 5.—Magnetic Collector.

sufficient under all circumstances. Fig. 3 is a cross-section, partly in perspective, Fig. 4 a plan, and Fig. 5 a longitudinal section of the line and electromagnet.

The experiments to which I have referred were undertaken to see whether the whole system is practically workable. The first question which presented itself was whether the wave in the strip running along at the speed

larger. In the first system elaborated by Mr. Lineff, the flexible underground shoe, with its trailing rope, required from 20lb. to 48lb. for its propulsion. In the series system the "arrow" rubbing through the "spring jacks" must necessarily also require the application of considerable force; but I have no figures on this point. In the new Lineff system the electromagnet rolls on the surface rail,

FIG. 6.—Path of Magnetic Lines.

of the car was likely to induce subsidiary waves either in front or behind the car, whereby exposed sections of the surface rail might become charged and be a danger to ordinary traffic. To investigate this matter a pilot brush was fitted to the car at different distances from its centre, and connected with an electric bell. The pilot brush was so placed as to slide over the surface rail, and if on a charged section the bell would sound. It was found that

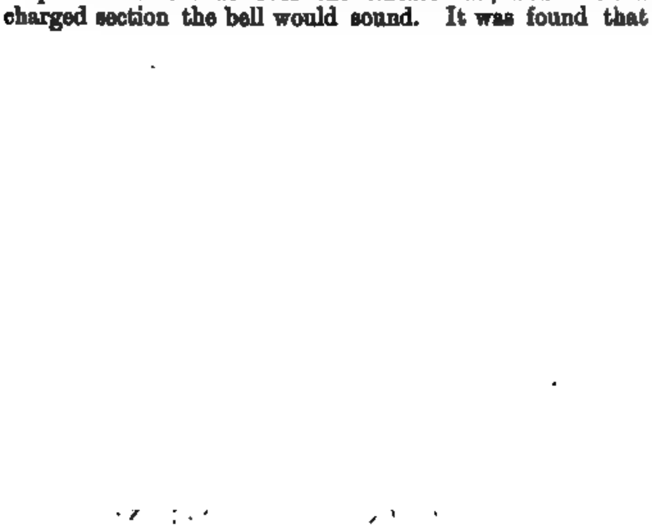


FIG. 7.—Magnetic Lines, thin hoop iron.

the charged region was at all speeds considerably shorter than the length of an ordinary car. Contact tests were also made over the whole line at greater distances from the car than the pilot brush could reach, and in no case have I found an exposed section of rail charged. There was, further, the danger that with a dry and dirty line the collection of current might be accompanied by sparking,

and the propelling energy is consequently small. I am informed by Mr. Lineff that he has succeeded in reducing it to 210 watts with the magnet energised. The whole power spent in collection of current is therefore about half a horse-power.

The insulation resistance of the conductor was tested both by the bridge method (48 Leclanché cells, Post Office

FIG. 8.—Magnetic Lines, ¼in. hoop iron.

pattern bridge, and mirror galvanometer), and by passing the leakage current through a voltmeter, and the two methods gave fairly accordant results. The highest reading I recorded by the voltmeter test, when the full pressure of 230 volts was on the conductor, was 5,400 ohms, and the lowest 3,550 ohms. From these figures it appears that the average insulation is 186 ohms per mile.

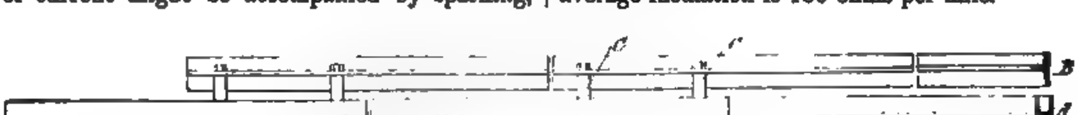


FIG. 9.—Method of Bolting Rails—Lineff System.

FIG. 10.—Method of Bolting Rails adopted in practice.

which would frighten horses; but this difficulty was overcome by fitting wire brushes to the pole shoes of the electromagnet.

An important point in all conductor systems of electric tramway is the energy spent in collecting the current. With the overhead wire system this is very small and practically inappreciable. With an underground system it is naturally

To ascertain the surface leakage I also applied the voltmeter test, and found the following insulation resistances of three charged sections of magnetic rail. With the line clear and moist, 4,183 ohms; with the line very wet and covered with mud and horse droppings, 980 ohms. Taking 2,000 ohms as an average, the loss of power at 300 volts by surface leakage per car amounts to 45 watts.

The mechanical strength of the line was tested by running a steam roller over it in various directions, under which treatment the line suffered no damage whatever.

Whilst the above paper was being read several very interesting magnetic figures were handed round to the audience. We reproduce three of these in Figs. 6, 7, and 8. Fig. 6 shows the paths of the magnetic lines in their course from one magnet pole to the other, backwards and forwards across the air gap between the hidden and surface rails. The position of the magnet poles N and S are as indicated. It will be observed that the courses of the magnetic lines show that the polarity is distributed as shown diagrammatically in Fig. 1, one surface rail intervening between the magnetic poles. Figs. 7 and 8 show the magnetic lines on a transverse section. In Fig. 7 the hoop iron is 6in. by No. 9 B.W.G., whilst that in Fig. 8 is 4in. by ¼in.

Fig. 9 shows the way in which the surface and buried rails have to be bolted together in pairs. The breaks in the buried rail are here represented as being placed half way between those of the surface rail, this arrangement being the best from a magnetic point of view. The mechanical disadvantage of having so much of the rail comparatively unsupported, has caused a modification such as that shown in Fig. 10 to be adopted in practice.

Most of the points raised in the discussion were fully dealt with in Mr. Kapp's report on the system published in our issue of Aug. 1. Major-General Webber's remarks as to the pressure used in the motor do not seem to have been clearly reported. With regard to the influence of the speed on the duration of the contact, he apparently considers that the danger of an active trail being left behind the car would increase as the speed was raised. Tests on this point, however, for speeds up to eight miles per hour (the maximum allowed for tramway traffic) show that the tendency is, if anything, in the opposite direction, and that the quicker the car travels, the shorter is the length of charged surface rail. In all cases this length is less than that of an ordinary car.

With regard to the cost of the conductor, we understand that this does not exceed £1,200 per mile of single line.

A view of the Lineff car in motion, being driven by a juvenile daughter of Mr. J. Seymour Keay, M.P., is given in Fig. 11.

Fig. 11.—View of the Lineff Closed Conduit Electric Car.

DISCUSSION.

Major-General Webber said they were very much indebted to Mr. Kapp for his description of the system. It was one which, he thought, met in a remarkable way a want which had been felt for a long time, assuming, of course, that nothing but underground conductors would be allowed by the authorities. Several engineers of the speaker's acquaintance had been directing their attention to the means of picking up contact in a duct underneath the surface, and which contained the copper conductor, and they had, he must confess, fallen short of the ingenuity displayed in the system suggested by Mr. Lineff. The description he had just heard showed that they might see daylight in that direction. He should like to draw the attention of Mr. Kapp to one or two points, on which the meeting was entitled to a little further information. Before proceeding further, the speaker pointed out one or two things, with diagrams, which were not quite clear. In the main, however, the diagrams gave a most excellent and graphic description of the way in which the magnetic field in the rolling magnet excited the rail. He felt, however, that there was absence of information as to the pressure which actuated the motor in the car. Supposing the pressure to be 500 volts, he failed to see that it was secure in preventing the rail remaining in contact after the passage of the car travelling at the rate of about 15 miles an hour, not particularly on the lines, but in the subways. Although the people did not walk in the subways, there was still a liability to accident if there resulted a permanent contact between the strip and the iron rails. In the absence of that information, he would also like to ask the size of the copper conductor to the work which requires to be done. He must confess some doubt as to the insulation of the conductor as shown on the diagram. Though it might be fairly good, there was the different

condition of highways, etc., and the question of weight, which at some time might break the whole thing to pieces. In conclusion, the speaker referred to the competition between the use of cable and electrical traction, considering there was a large field for work.

Mr. Preece said he had only to add to what Mr. Kapp had said by stating that he had inspected the working of the system near Chiswick, and he corroborated every word that the reader of the paper had said. His (the speaker's) fears of practical success of the system were, principally, that there might be a failure of contact; but this was got over, first, by having a very broad strip and very lengthy contact, and also by the fact that the flexible iron conductor is galvanised and, therefore, always clean. Moreover, the galvanisation on the surface has exactly the same effect as the insertion of pieces of paper on the pole-pieces of electromagnets. Of all systems produced this had an air of practicability about it, but it would be quite impossible to give a definite opinion upon it until it had received the test of actual practice. His impression was that the tramway company which served the district about Kew would lay down three or four miles of the system, and he hoped when they met at Cardiff next year that Mr. Kapp would be able to tell us the results of an absolute practical test.

Prof. Arnold Lupton made some remarks on the insulation of the rails and the falling of the strips, but his remarks were indistinctly heard.

Mr. Sellon said there were one or two questions he would like to ask. They had not had any detail as to the cost, which was naturally the first thing of a tramway engineer. Although Mr. Kapp had said the system could only be an advantageous system in the particular districts, because no other system would be allowed in the districts, he did not see why other electric systems should be thrown out because Mr. Kapp wished to introduce Lineff's system. He would have been glad if Mr. Lineff had joined hands with them in the late fights in Parliament against telephone companies. If the telephone companies were going to have their clauses introduced into their Bills for electric traction, neither Mr. Lineff's system nor any other system by which the return wire coming through earth could be used. One great difficulty he saw with the system is whether the contact is always going to drop directly the car passes over at great speed. He desired, before sitting down, to draw Mr. Kapp's attention to the telephonic clauses, and he asked the question as to the cost per mile and its absolute efficiency from its generating station at the car motor.

Prof. Ewing said how much one must admire the exceedingly ingenious method by which Mr. Lineff had solved the fundamental magnetic difficulty in the problem. They had here a strip and a sufficient amount of mechanical force; the action upon the iron strip occurred only when the iron rail above it was interrupted, and if the longitudinal action had been made use of it would have been necessary to cut a longitudinal rail into an inconveniently large number of sections: but by the exceedingly simple device of employing a supplementary rail cut into comparatively long sections, Mr. Lineff had succeeded in grasping his conductor not at one or two points only, but almost the whole length under the car. It was impossible not to admire, from the magnetic point of view, the exceedingly ingenious solution of the difficulty. Something after the same system has been before the public as a proposal for a number of years—namely, the system originally introduced by Messrs. Ayrton and Perry, having a thoroughly well insulated conductor underground, which was to be connected when the car passed with successive sections of a not so well insulated conductor serving as a service conductor. This was exactly what Mr. Lineff did, though, of course, in a very much more satisfactory way than the mechanical methods practised by Ayrton and Perry.

Mr. Swinburne wished to emphasise what Mr. Sellon had said. It was an important question that of the telephones, and one hardly knew what would happen unless the thing could be settled. Insulated returns were insisted on, which was a tremendous drawback to electric traction.

Major-General Webber said that with regard to the telephone, they could next year dismiss this fear from their minds, for he had every reason to believe that almost all the telephone systems in this country would be served by metallic returns and not by earth returns, in which case it would not be necessary to insist on such clauses.

Mr. Kapp, before entering into the technical questions, said he would reply to Mr. Sellon. He wished it to be clearly understood he had not any interest whatever in bringing forward the Lineff system. He placed before them the result of careful investigations without comment. He did not wish, as Mr. Sellon had said he wished, to throw out any other system of electric traction; for his part, he would be glad to see it go ahead a little faster. English town councils (and they must reckon with the powers that be) would not tolerate the overhead wires, and, consequently, engineers must work with the underground or some other system, and often the town council, as was the case in the Hammersmith Vestry, had so tender a regard for cyclists, as to prohibit the use of the slot in the street. The difficulty in disturbing the telephone wires was overcome by working the tram lines on the three-wire system, the down line connected with the positive and the up with the negative, and the third wire put to earth, which resulted in a differential current, which was small, going to earth. He was sorry that he did not explain that the current went back to the station in the usual way: but, of course, they could have a second conductor if they wanted to work a close circuit. The system of duplicating the telephone wires was far preferable. They all knew the bad telephones in London, and they would be better if that were adopted. In regard to the question asked by General Webber about the strip remaining in contact, he was sorry he did not make it quite clear; the strip did not remain in contact. He had a fear that the residual magnetism would be enough to keep up the strip, and another fear was the main wave under the car, by some way jerking the strip would induce subsidiary waves and make a contact; but he (the speaker) had tried in many ways to make this contact, but had not succeeded. General Webber evidently thought the contact would be due to the voltage, but the residual magnetism did not prolong the contact, which was the reason that galvanised covering was used. As to the enquiry about insulation, what he had put on the blackboard was the line as it was actually built, but since the line had been finished Mr. Lineff, who had a most ingenious mind, had improved the general arrangement of the surface, and hoped thereby to get a very much higher insulation. As to failure of contact, a part of Mr. Lineff's work was to provide means whereby the strip could be drawn out and a new strip drawn in, if it were found the strip fell down. One gentleman had asked how this one-car system could be worked. The system of working tramways most in use was known as the parallel working system. The conductor which brings the current was tapped by each car, which drew off sufficient current to give motive power; but there was nothing to prevent the second car tapping the said conductor. It was a well-known system of tramways, which had been used in many cases. An ascending car would tap off a little more electricity, and a descending car may tap off a little less, or it may give back a little if the descent was strong enough. As to whether there would be any noise from the strip, there would be absolutely none whatever. As to the question of cost, he knew what Mr. Lineff's estimate was, although he did not know whether it was correct, the cost would be £2,000 a mile, which was a little heavier than overhead conductor, but not much.

THE MIDDLEMAN IN ELECTRIC LIGHTING.*

Did the framers of the Electric Lighting Acts, 1882 and 1888, contemplate the creation of a body of middlemen between the Board of Trade and the actual suppliers of electricity? What would be the effect upon the electrical industry of the institution of such a body? Such were the questions which a short time ago greatly exercised the mind of the electrical world. They were consequent upon the reported decision of the Board of Trade (favourably discussed by a correspondent in the *Times*) to concede to local authorities the right to transfer to "any company or person" the powers, duties, and liabilities" incident to the possession of a provisional order. A deputation from metropolitan electric supply companies had an interview upon the subject with the President of the Board of Trade, and placed before him the grounds for their belief that the powers asked for by the local authorities were in contravention to the spirit of the Electric Lighting Acts, and would, if granted, prove a bar to progress.

It was argued, *inter alia*, that although upon the face of it the qualifying words, "without the consent of the Board of Trade," added by the Lords Committee to the eleventh clause of the Bill of 1882, as it left the Select Committee of the House of Commons, did seem to favour the notion of a contemplated power of transfer, the limits of that power were pretty clearly defined by the fact that it was to be possessed equally by local authorities and by private undertakers. "No local authority or person"—so the prohibition reads—"shall by any contract or assignment transfer to any other company or person or divest themselves of any legal powers given to them, or any legal liabilities imposed on them by this Act, or by any license, order, or special Act, without the consent of the Board of Trade."

The most, apparently, that could be said upon this was that circumstances were conceived which, equally in the case of a corporation and of a company, might justify or make desirable the transfer of an order, and that the Board of Trade was thereupon authorised, if it saw fit, to sanction the transfer. Evidence confirmatory of the correctness of this view was to be obtained by an examination of the proceedings of the Select Committee of the House of Commons on the Bill Mr. R. S. Wright, counsel for the Liverpool and other corporations, proposed a broadly-worded clause, ostensibly to empower local authorities under the Act to contract with companies or individuals for the construction and the maintenance during a fixed period of electric lighting installations. But Mr. Chamberlain thought that the terms of the proposed clause were comprehensive enough to confer the very power of delegation now sought, and he objected. Upon which Mr. Wright expressly disclaimed, on behalf of the corporations, the wish for any such concession, and he suggested, with the avowed object of preventing such a use of a provisional order, the addition to his clause of the qualifying words afterwards adopted by the Lords. The committee, however, after some full consideration of the point, rejected Mr. Wright's clause, and substituted for it one which absolutely and without qualification prohibited a transfer. Thus, neither from the terms of the eleventh clause itself—and this clause is in no wise inconsistent with the general tenour of the Act—nor from the evident intentions of its framers, as shown also in other provisions of the Act, did it seem possible to make out a case for the exceptional treatment proposed to be accorded by the Board of Trade to local authorities. The President of the Board of Trade has, however, a child-like confidence in the wisdom

* From the *Times*.

and the impeccability of mayors and corporations that is really pathetic. He has since inserted in a few orders the clause asked for, and it is understood that a precedent has been established for all similar orders. The final decision rests, of course, with Parliament, and the question is still arguable.

What will be the effect of this new departure? The immediate effect will, in all probability, be a considerable increase in the applications for provisional orders by local authorities. Not, of course, with the view of supplying electricity themselves; this they could have done, without waiting for a transfer, any time these years past. Not, either, as is sometimes alleged, to acquire more complete control over the necessary mainlaying, etc., in their streets, it being almost inconceivable that more effective control could be devised than that already in force under the model order of the Board of Trade. Their functions will be those of middlemen, of prejudicially interested middlemen, in many cases (as will presently be shown), with the power and the motive to farm out their order on terms more onerous than those conceded by the Electric Lighting Act of 1888; traders not in electric lighting—that would be a legitimate, if an inadvisable, policy—but in an Act of Parliament. The thing is an anomaly, and a vicious one. If, as there is reason to believe, the correspondent in the *Times* before referred to may be accepted as their spokesman, the chief aim of these newly-constituted middlemen will be, as might naturally be supposed, to considerably shorten the tenure of supply allowed by the above-mentioned Act—to revert, in fact, as closely as possible to the 21 years' tenure of the Act of 1882. They would rather not take the risks, but the profits, should there be any; these they would like to pocket at an earlier date than the Act provides for. Can this be done without checking, without arresting altogether, it may be, the further development of electric lighting? The precedent of 1882 would seem to supply an emphatic negative. It would be idle, of course, to deny that since the passing of that Act electrical engineering has made considerable advance, especially in the direction of an economical distribution of electricity over large areas. But it is equally futile to attribute to electrical shortcomings, as some interested people do, the paralysis of electric lighting enterprise which, following upon the legislation of 1882, continued up to that of 1888. The whole question was exhaustively dealt with by the Select Committee of the House of Lords in 1886. It was then shown (by Sir Frederick Bramwell and Prof. Forbes) in particular that on the Continent and in America, where confiscatory purchase clauses did not exist, electric supply from central stations had long been an established industry, and a successful one. They declared that electrical science was at least as advanced in England as elsewhere; the difference in the work accomplished was the difference between science unfettered and science fettered by repressive legislation. Their conclusions were emphasised by men of the financial status of Sir John Lubbock, Mr. Hucks Gibbs, and the late Mr. Lionel Cohen, who agreed that no capitalist would look at an electric lighting company with a tenure in any wise approaching to 21 years, to be terminated by the compulsory sale of its undertaking for the mere value of the plant, etc. From the evidence given before them the committee arrived at the conclusion that to remove the bar to progress that the Act of 1882 had imposed, to give elbow-room to private enterprise, an extension of tenure to 42 years was absolutely necessary; the result was the Electric Lighting Act of 1888. Since then, at any rate, no economising improvement has been introduced into the industry, no more favourable conditions exist to convert the capitalist to the belief that a tenure which he pronounced, and the committee acknowledged, to be impossible in 1886 would be remunerative in 1890. The inference is obvious and irrefutable.

It will be plain, indeed, from the following, among other considerations, that in the very nature of the case a short tenure would not lessen the number of dividend-earning years; it would lessen the chances of earning any dividend at all. The Electric Lighting Act of 1888 is an improvement upon its predecessor only in the direction of a lengthened tenure of supply; the conditions of compulsory purchase remain practically the same. Now, as then, the local authority within whose area electricity is being supplied may require the supplying company, at the expiration of the statutory term, to sell to them its undertaking upon terms of receiving "the then value of all lands, buildings, works, materials, and plant suitable to and used for the purposes of the undertaking"; all other considerations that usually attach to the sale of a business (goodwill, past and prospective profits, etc.) being expressly excluded. Laywers are said to have discovered in the terms of the section an ambiguity favourable to the seller. If it exists, local authorities, in making terms with their lessees, may be trusted to act upon the suggestion of the *Times* correspondent, and to remove it.

Now, the amount that would be refunded to the company by the sale of their undertaking on such terms as these must of necessity represent but an infinitesimal part of the total capital that would have been spent in the building up of the business. The deficiency must be provided for somehow. A sinking fund, large in proportion to the shortness of the tenure, must be set aside out of income for the redemption of capital. The larger the sinking fund the higher must the charge be for electricity, the more disadvantageously must electric light compete with its cheaper rival, gas, and the more restricted in consequence must be the area of possible supply. The conclusion is inevitable that to what extent soever you may succeed in reducing the tenure of supply authorised by the Act, to just that extent you handicap, unfairly handicap, the electric light in its competition with gas; to just that extent you lessen its attractiveness for the prudent investor. The injury extends to the ratepayer, whose "interests" are to be jealously guarded. He would suffer, too, by paying an unnecessarily high price for the electricity he would consume.

There is another consideration and a very important one. Nobody supposes that the last word has been said upon the question of dynamic machinery. Electricalscience will probably stride onward to discovery, to improvement. Can it be expected that a company which, on arriving at mere maturity, has to look only for extinction, can it be expected that such a company would be eager to adopt improved methods of supply? Who would subscribe the capital for the purchase? It may be answered that an arbitrator would be bound to take into his consideration, in awarding the price of the undertaking, the greater suitability of the new methods for the purposes of the undertaking. Possibly; but would he award anything at all for the old and discarded machinery—machinery, it must be remembered, which would still have served to earn dividends? Here would be a dead loss. Thus a short tenure would have also a tendency to discourage invention. The writer does not profess to be in the secrets of Capel-court, but he is told that "the City" is by no means rampant to invest in electrical undertakings, even under a 42 years' tenure. Under less favourable conditions either electric supply would not be undertaken at all or it would be embarked upon by rash speculators and developed into a failure.

The foregoing are intended as reasons against the placing in the hands of any local authority the power to practically annul the provisions of an Act of Parliament and to arrest the progress of electrical enterprise. Their force must, it is evident, be immensely increased when it is remembered—it is impossible to ignore that fact in this connection—that a large number of these local bodies are owners of gas undertakings. Upon the profitable working of those undertakings depends the security of vast sums of borrowed money. The introduction of electric light might endanger that security. It is not necessary to impute corrupt motives in order to appreciate at its proper value the *vis inertia*, the active opposition even, to be naturally looked for in public bodies so prejudicially interested. They are guardians of the "interests of the ratepayers," they are ratepayers themselves, they are mortal men. To shut out all other applicants they, too, will obtain provisional orders. They can hardly be expected to cut their own throats by working them themselves; will they do so indirectly by the concession of favourable terms to lessees?

The unfairness to the new industry of granting to bodies so circumstanced the power to veto the introduction into their town of a competing illuminant was recognised by several members of the Lords' Select Committee of 1886. Lord Ashford and Lord Balfour of Burleigh especially made several efforts to so modify Clause 1. of the Bill as to exclude gas-owning corporations from those local authorities whose consent was to be necessary to the granting of a provisional order to private undertakers. Their efforts were, unhappily, not successful. And the result hitherto? The result has been to render the Act a dead letter in the case of all towns so governed. Local authorities have ruled the roost.

It is in this direction that a new departure is desirable, a more liberal interpretation, that is to say, by the Board of Trade, of those special circumstances which, in view of the framers of Section I. of the Act of 1888, would justify the grant of a provisional order without the consent of the local authority. It would be a mere beating of the air to argue against the policy of extending the commercial functions of municipal bodies. For good or for evil, the tendency is in that direction; communism is in the ascendant. But it may not be amiss to insist upon the elementary truth—it is too often lost sight of—that private capital will not take the risk of developing, or of failing to develop, a new enterprise for the simple good of the community. It is very selfish, but then the millennium has not dawned yet. Until it does, human nature will probably continue to be pretty much as it has been, and the prudent investor will decline to have anything to do with undertakings that are to be transformed by local authorities on the principle of "heads I win, tails you lose."

Parliament might, perhaps, do many worse things than to decline even yet to sanction the delegation to such bodies of powers which, it is morally certain, will be used to nullify, at least for a long time, the most generous provision of the not too generous Act of 1888. The general tendency of modern legislation, of humanitarian effort, is to depose the middleman and the sweater. What has the electrical interest done, it might be asked, to deserve an invidious distinction?

Electric Lamps as Speed Counters.—A new use for electricity has been found at the Cook publishing house in Elgin, says an Illinois paper. In the office of the superintendent 10 electric lamps are arranged in separate compartments of a frame or box, somewhat similar in appearance to the annunciators seen in hotel offices. The lamps are concealed from view, apertures in front of the compartments being covered with coloured glass, each having its distinguishing colour. The lamps are connected by means of electric wires with the automatic counting machines on the 10 large printing presses located in an adjoining building. When the presses are in operation the electric circuit is opened and closed by the working of the counting machines, causing quick flashes of light in the lamps. Thus every sheet of paper printed in the establishment telegraphs its record to the office, where the operation of each machine can be seen and its speed or delays noted

THE

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

MIDDLEMEN.

The *Times*, in an article which we reprint in another column, has given one version of the case between would-be suppliers of electrical energy and the Board of Trade, or rather the House of Commons. Much of what is stated in the article is perfectly true, and will be agreed to by all engaged in the industry. On the other hand, some of the points are disputed. There is only one point in the article upon which we shall at present comment adversely. It is a point which has done, is doing, and will do much harm. Referring to the Select Committee of the House of Lords in 1886, we are told "It was then shown (by Sir Frederick Bramwell and Prof. Forbes) in particular that on the Continent and in America, where confiscatory purchase clauses did not exist, electric supply from central stations had long been an established industry, and a successful one. They declared that electrical science was at least as advanced in England as elsewhere, the difference in the work accomplished was the difference between science unfettered and science fettered by repressive legislation." Now, while there is a modicum of truth in this argument, it is really very far from representing the true facts of the case. The progress made in America was made, in the first place, because electricity had not to compete in the majority of cases with an illuminant in full possession; in the second place, where it had to compete with another artificial illuminant such as gas, the cost of the gas was very much in excess of what it is in England; and, thirdly, the Americans were quick to realise that "more light" in the streets was a paying game. In a very large number of cases the American town authorities had, as we say, to decide what the artificial light of the streets should be, there being then none existing. Naturally they considered the value of the arc light, its initial cost, and the cost of maintenance, as against the cost of a gas works. Moreover, the geometrical plan of their streets lent itself to arc lighting more than the grown-up-bit-by-bit-without-plan streets of English towns. The result was great activity in electric light installations. Further, in America they wanted the light, and the towns being young and vigorous, with none of the effete æstheticisim of the older English towns, no objection was raised to overhead wires. But not one per cent. of these installations can be termed central station installations. They were not put down for general lighting, only street lighting, and if the lighting of interiors has extended it has grown up after the success of the external lighting was proved. We contend that if America had legislated on the question for artificial light during the period from 1880 to 1890, all methods would have been put on the same footing as regards "confiscatory purchase" by the municipalities. The progress in

America, then, has been largely due to the difference of conditions existing, and has had nothing to do with legislation. With regard to the competition of electricity with gas in America, it must never be forgotten that gas costs them something more than two or three shillings a thousand. If in London, Liverpool, Manchester, or any other large town gas costs eight or ten shillings per thousand cubic feet, the introduction of electricity would be viewed very differently to what it is now. Our remarks are intended to refer simply to external lighting—to arc lighting, in fact; for most of our readers fully understand that we consistently refuse to admit that it is fair to argue for or against electricity for interiors because it is or it is not dearer than gas. In this case indirect as well as direct expenditure must be considered, as well as certain properties of electric lighting which are less prejudicial to health than is gas lighting. The Americans, we say, realise the necessity of "more light" in the streets. They are a go ahead people, and find business can be transacted more quickly and better with a good light than with a bad one. It does not suit them that a horse shall take three hours to go from place to place, or men take three hours to load a truck, when with more light the work could comfortably be done in half the time. Apply this to London—to its streets, its stores, its warehouses. Double the consumption of gas in order to give more light, and men would prefer Aden or Suakin as towns in which to work.

The question of transfer has been previously discussed in these columns, and we venture now merely to say a few words in regard to the compulsory purchase. Of course this is the nut, and a hard one it is to crack. The electrical industry naturally desires a free hand, but surely it must be admitted that the local people have also something to say in the matter. For many reasons they may desire to have the lighting in their own hands, and the private adventure company may have no objection to that course. In an ordinary business if such a transfer were desired, technical valuers would be engaged by each party and independent valuations made. The valuers would probably either agree or approximately agree, but if necessary because of non-agreement in the case of electric light installations, the Board of Trade might have been appointed arbitrators. Under the existing law confiscation is possible, and to guard against loss by such confiscation, the supply company during the 42 years or other period of its tenure has to make provision. If at the end of the period a fair price is given as for a going concern, then possibly the provision made to guard against eventualities is an unwarranted and unnecessary imposition upon purchasers. The *Times* puts all this very fairly, but much more might be said, for if the company does throughout its period of tenure charge a higher price to make provision against loss, its balance-sheet viewed as a going concern is too good, and price based upon this balance-sheet would be too high—hence the ratepayers would, if they bought the concern, pay very much more than if no overcharge had been made. It would be rather hard to pay more because they had already paid too much. This, it seems, is one of the jumbles bred of confiscation.

If, as seems likely, local companies are formed to supply electricity, it is more than probable that when the local authorities determine to buy, an attempt will be made for equitable purchase on a business footing as a going concern, and how then will the purchaser treat the point just raised? Valuers may try, but it will be no easy task to give satisfaction. View the question in any shape, there is but one solution. Abolish the confiscation scheme, and let the question of purchase be fought upon its merits between the two contracting parties. There may be a time stated after which compulsory purchase may take place, but the price to be paid is not to be cut and dried beforehand.

LEEDS.

Those who have had negotiations with Leeds concerning the electric light have not always been satisfied with the result. However, there seems to be a tendency to go forward, not only with lighting but also with traction. Last week at the meeting of the Leeds County Council the report of the committee, recommending the Council to undertake the supply of lighting by electricity was brought forward, the discussion being adjourned to Monday last, when an amendment was moved and carried to the effect that it was not desirable for the Corporation itself to supply electricity for lighting purposes, and that it can be more advantageously supplied by private enterprise. The peculiarity of the discussion arises in the fact that the mover and seconder of the motion to adopt the report of the committee voted for the amendment. This too, after the matter had been three times before the Council and three times referred back to the committee, while the report states that "with absolute unanimity and strong conviction" they express their opinion against further delay, and recommend, as in the previous report, the Corporation should undertake the work. Another portion of the report stated that for a large area the Corporation could supply the electric light at the rate of ⅛d. per 10-c.p. lamp per hour, equivalent to a charge of 3s. 5d. per 1,000ft. of gas, at a rate about one-half the price now charged by a private company. It is difficult to reconcile the voting with these statements.

CORRESPONDENCE.

AN ELECTRIC HAMMER.

To the Editor of The Electrical Engineer.

Sir,—In reference to your note on Van Depoele's electric hammer, p. 280 of your last issue, permit me to say that Marcel Deprez, in 1882, constructed a hammer on apparently exactly the same method. Deprez's hammer was described and illustrated in *La Nature* (Paris) about the end of July, 1882. It consisted of a solenoid about one metre long, composed of a series of flat coils, superimposed on one another and forming a hollow cylinder, within which a core of soft iron, weighing about 25 kilogrammes, was free to move. The coils to the number of 80 were so connected that the last turn of wire of the first was joined to the first turn of wire of the second, and so on. All these coil connections were connected to a circular commutator. The brushes were moved by a double handle. The connections before the brushes and the source of current were so arranged that the current entered by one brush and left by the other, after having traversed 10 of the coils, which were in connection with the 10 commutator plates included between the brushes. Thus the current could be admitted into the higher or lower coils of the solenoid by turning the commutator handle, and the core, or hammer, could be raised and lowered accordingly. It was stated that the blows could be regulated with great nicety, and that with a current of 43 amperes and five coils energised, the weight of the blow struck was 70 kilogrammes. Don't you think that if there had been anything in Deprez's hammer it would have been heard of practically before now? What's the use of wasting energy in wires when you can utilise it so much more directly by means of steam? And where's the future for the electric hammer? Yours, etc., Wildmoor.

Hampshire, 4th Oct., 1890.

PRACTICAL v. PROFESSIONAL.

To the Editor of The Electrical Engineer.

Sir,—Your remarks on the insufficiency of theory are at the present moment very interesting. Prof. FitzGerald is perfectly correct in saying that those responsible will not pay a proper price for data or other theoretical information; they prefer paying a thousand times as much in tedious experiment. One of my first customers thought five guineas too much to pay for information about certain worthless patents, and he refused to pay it. The engineer's bill and the law proceedings cost him £7,000, including £2,000 paid for the patents.

Electricity, especially in its present experimental stage, calls for a very great acquaintance with its mathematics and practice, and the want of that knowledge has occasioned the waste of large sums of money.

Much has been written lately about the uselessness of mathematics, but one view of the question has not been noticed. Mathematical knowledge is of small direct use compared with its indirect advantage. Probably none of us recollect much of Euclid, especially the eleventh and twelfth books and the Data; but they have had their effect on our minds in giving us a power of analysis, although they are now forgotten, just as the sun and water bleach linen without leaving any trace behind them. And so with the highest branches of the Calculus, the direct use of which is far greater. It is most essential that theoretical and practical knowledge be combined in the same man.

We want better books, and there are indications that we shall have them. Maxwell or Watson and Burbury are invaluable for the high mathematician; but there were few books of any real value for the practical student who had little to spend until Slingo and Brooker's book appeared. The majority of the cheap books were paste and scissors, with a few hastily-contrived paragraphs to modernise them, and at the same time make them ridiculous. I wish someone would write such excellent modern treatises as Dr. Lardner published in 1856, and the same low price of five shillings.—Yours, etc., C. Purcell Taylor.

JARMAN'S ELECTRIC TRAMCAR.

On Thursday last week the Jarman Electric Tramcar Syndicate held a public trial of their accumulator car. We were not present owing to this being our press day, but we went up on Tuesday, when we inspected the car and works, but did not see the car run. We are informed by one who was at the trial that, unfortunately, an accident, of a similar nature to that which occurred to the Elieson cars, happened—namely, that the car would not take the points, and was run at them several times, and finally a large piece of the wheel broke off. This was doubly unfortunate at a trial, and we believe a further trial is to be carried out.

The engine-house in use by the Jarman Syndicate is situated at 158, Clapham High-road, near the Plough Inn. The premises belong to the London Tramways Company, who have also lent one of their cars to be fitted electrically. A portable engine of 16 h.p. nominal drives a Westminster dynamo of Clark, Muirhead and Co.'s manufacture, capable at 1,000 revolutions of giving 160 amperes and 120 volts. This is used for charging the accumulators employed on the cars.

The Jarman car is a self-contained storage battery car, fitted with a strong mechanical gearing of wrought iron against vulcanised fibre teeth, and driven with an arrangement (which is supposed to be the speciality and beauty of the Jarman system) of two motors coupled together on one shaft. We have already commented upon the system, judged principally from the point of view of asking the public large sums of money for it as an invention, and do not see any need to change our opinion. We do not say that it will not or cannot work, but simply that wherein the arrangement of two motors in one shaft is peculiar, it is no improvement. The system will work, and possibly work both well and cheaply (a question of cells rather than of motors), and we trust the Jarman Syndicate will be able to obtain and successfully exploit contracts. But that the use of the weight and expense of two motors instead of one double the power is any improvement mechanically we are not at all prepared to admit.

We will, however, describe the arrangement adopted, and explain what Mr. Jarman (who is indefatigable in his exertions for its success) considers the benefits. To start a car, double the power is required momentarily, therefore Mr. Jarman employs two motors which can be worked together at starting or uphill, while on the level one motor only is worked. Again, to start a motor, resistance must be put in the fields to prevent the rush of current burning the armature. The energy of the current sent through the resistance is lost in heat in the coils. Mr. Jarman winds extra fine coils on his field magnets, using this resistance to reduce the rush of current, and utilising the extra coils to aid the field magnets in initial torque, so that no exterior resistance whatever is employed. The switch consists of an upright stand, having connections which successively put in these extra coils, put the two motors in series, or in parallel, or cut one of them out altogether, corresponding with full speed, normal, half, and slow speed, both backward and forward. A strong railway block brake controls the wheels, and the car, it is stated, can be pulled up within 4ft. at ordinary speed. The motors are comparatively slow-speed motors—650 revolutions—and are of 7 h.p. each, making 14 h.p.

The arrangement for the cells is adopted for the least possible alteration to existing cars. Openings are made at each end, and swing doors of louvre-boards are made to open into the space under the carriages. A corresponding hinged door is made in the exterior iron protector of the car. The whole trayful of cells is then pushed in lengthwise. This will be done by mechanical or hydraulic action. The louvre-board doors allow of free ventilation of the cells as the car moves along. The car contains 52 double storage cells (*i.e.*, 104 small cells), E.P.S. make, of 19 plates each, weighing 1 ton 18cwt. The car and motor weighs 5½ tons, and the total weight loaded is 8 tons. The current drawn out averages about 25 or 30 amperes, varying from 6 amperes on lighted load up to 50 amperes on the heaviest grade of 1 in 18 up Balham-hill. On

starting, the current shows 60 amperes momentarily for a second or so. The set of cells in use have been working three years with at present only one cell gone bad. Experiments made by weighing fuel have shown Mr. Jarman that the cost of fuel only is 1¼d. per car mile. To this will be added depreciation, superintendence and fixed charges, and Mr. Jarman is confident of being able to make a profit at the price of 4½d. per car mile, which has been so often mentioned for storage cars. A second car has been built and is practically ready, and 12 cars are eventually to be built. It is expected that arrangements will be made shortly for running the electric cars amongst the horse cars on schedule time. Mr. Jarman states that a complete plant for and including six cars with cells, motor, engine, dynamo, and including all fittings, can be supplied on his system for £5,000.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

LECTURE I.

(Continued from page 289.)

GENERALITIES CONCERNING ELECTROMAGNETS.

Materials.—In any complete treatise on the electromagnet it would be needful to enumerate and to discuss in detail the several constructive features of the apparatus. Three classes of material enter into its construction; first, the iron which constitutes the material of the magnetic circuit, including the armature as well as the cores on which the coils are wound, and the yoke that connects them; secondly, the copper which is employed as the material which conducts the electric currents, and which is usually in the form of wire; thirdly, the insulating material employed to prevent the copper coils from coming into contact with one another, or with the iron core. There is a further subject for discussion in the bobbins, formers, or frames upon which the coils are in so many cases wound, and which may in some cases be made in metal, but often are not. The engineering of the electromagnet might well furnish matter for a special chapter.

TYPICAL FORMS.

It is difficult to devise a satisfactory or exhaustive classification of the varied forms which the electromagnet has assumed, but it is at least possible to enumerate some of the typical forms.

1. *Bar Electromagnet.*—This consists of a single straight core (whether solid, tubular, or laminated), surrounded by a coil. Fig. 3 (p. 244) depicted Sturgeon's earliest example.

2. *Horseshoe Electromagnet.*—There are two sub-types included in this name. The original electromagnet of Sturgeon (Fig. 1, p. 244) really resembled a horseshoe in form, being constructed of a single piece of round wrought iron, about ½in. in diameter, and nearly a foot long, bent into an arch. In recent years the other

FIG. 11.—Typical Two-Pole Electromagnet.

FIG. 12.—Iron-clad Electromagnet.

sub-type has prevailed, consisting, as shown in Fig. 11, of two separate iron cores, usually cut from circular rod, fixed into a third piece of wrought iron, the yoke. Occasionally, this form is modified by the use of one coil only, the second core being left uncovered. This form has received in France the name of *aimant boiteux*. Its merits will be considered later. Sometimes a single coil is wound upon the yoke, the two limbs being uncovered.

3. *Iron-clad Electromagnet.*—This form, which has many times been reinvented, differs from the simple bar magnet in having an iron shell or casing external to the coils, and attached to the core at one end. Such a magnet presents, as depicted in Fig. 12, a central pole at one end surrounded by an outer annular pole of the opposite polarity. The appropriate armature for electromagnets of this type is a circular disc or lid of iron.

4. *Coil and Plunger.*—A detached iron core is attracted into a hollow coil, or solenoid, of copper wire, when a current of electricity flows round the latter. This is a special form, and will receive extended consideration.

5. *Special Forms.*—Beside the leading forms enumerated above, there are a number of special types, multipolar, spiral, and others designed for particular purposes. There is also a group of forms intermediate between the ordinary electromagnet and the coil and plunger form.

POLARITY.

It is a familiar fact that the polarity of an electromagnet depends upon the sense in which the current is flowing around it. Various rules for remembering the relation of the electric flow and the magnetic force have been given. One of them that is useful is that when one is looking at the north pole of an electromagnet, the current will be flowing around that pole in the sense opposite to that in which the hands of a clock are seen to revolve. Another useful rule, suggested by Maxwell, is illustrated by Fig. 13—namely, that the sense of the circulation of the current (whether

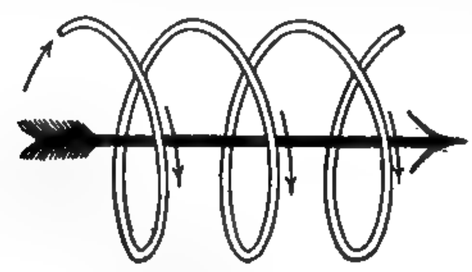


FIG. 13.—Diagram illustrating Relation of Magnetising Circuit and Resulting Magnetic Force.

right or left-handed), and the positive direction of the resulting magnetic force are related together in the same way as the rotation and the travel of a right-handed screw are associated together. Right-handed rotation of the screw is associated with forward travel. Right-handed circulation of a current is associated with a magnetic force tending to produce north polarity at the forward end of the core.

USES IN GENERAL.

Regarded as a piece of mechanism, an electromagnet may be regarded as an apparatus for producing a mechanical action at a place distant from the operator who controls it; the means of communication from the operator to the distant point where the electromagnet is being the electric wire. The uses of electromagnets may, however, be divided into two main divisions. For certain purposes an electromagnet is required merely for obtaining temporary adhesion or lifting power. It attaches itself to an armature, and cannot be detached so long as the exciting current is maintained, except by the application of a superior opposing pull. The force which an electromagnet thus exerts upon an armature of iron, with which it is in direct contact, is always considerably greater than the force with which it can act on an armature at some distance away, and the two cases must be carefully distinguished. Traction of an armature in contact, and attraction of an armature at a distance, are two different functions. So different, indeed, that it is no exaggeration to say that an electromagnet designed for the one purpose is unfitted for the other. The question of designing electromagnets for either of these purposes will occupy a large part of these lectures. The action which an electromagnet exercises on an armature in its neighbourhood may be of several kinds. If the armature is of soft iron, placed nearly parallel to the polar surfaces, the action is one simply of attraction, producing a motion of pure translation, irrespective of the polarity of the magnet. If the armature lies oblique to the line of the poles there will be a tendency to turn it round, as well as to attract it; but, again, if the armature is of soft iron the action will be independent of the polarity of the magnet, that is to say, independent of the direction of the exciting current. If, however, the armature be itself a magnet of steel permanently magnetised, then the direction in which it tends to turn, and the amount, or even the sign of the force with which it is attracted, will depend on the polarity of the electromagnet, that is to say, will depend on the direction in which the exciting current circulates. Hence there arises a difference between the operation of a non-polarised and that of a polarised apparatus, the latter term being applied to those forms in which there is employed a portion, say an armature, to which an initial fixed magnetisation has been imparted. Non-polarised apparatus is in all cases independent of the direction of the current. Another class of uses served by electromagnets is the production of rapid vibrations. These are employed in the mechanism of electric trembling bells, in the automatic breaks of induction coils, in electrically-driven tuning-forks such as are employed for chronographic purposes, and in the instruments used in harmonic telegraphy. Special constructions of electromagnet are appropriate to special purposes such as these. The adaptation of electromagnets for the special end of responding to rapidly alternating currents is a closely kindred matter. Lastly, there are certain applications of the electromagnet, notably in the construction of some forms of arc lamp, for which it is specially sought to obtain an equal, or approximately equal, pull over a definite range of motion. This use necessitates special designs.

THE PROPERTIES OF IRON.

A knowledge of the magnetic properties of iron of different kinds is absolutely fundamental to the theory and design of electromagnets. No excuse is therefore necessary for treating this matter with some fulness. In all modern treatises of magnetism the usual terms are defined and explained. Magnetism which was formerly treated of as though it were something distributed over the end surfaces of magnets, is now known to be a phenomenon of internal structure; and the appropriate mode of considering it

* Cantor lectures, delivered before the Society of Arts.

is to treat the magnetic materials, iron and the like, as being capable of acting as good conductors of the magnetic lines; in other words, as possessing magnetic permeability. The precise notion now attached to this word is that of a numerical coefficient. Suppose a magnetic force—due, let us say, to the circulation of an electric current in a surrounding coil—were to act on a space occupied by air, there would result a certain number of magnetic lines in that space. In fact, the intensity of the magnetic force, symbolised by the letter H, is often expressed by saying that it would produce H magnetic lines per square centimetre in air. Now, owing to the superior magnetic power of iron, if the space subjected to this magnetic force were filled with iron instead of air, there would be produced a larger number of magnetic lines per square centimetre. This larger number in the iron expresses the degree of magnetisation in the iron; it is symbolised* by the letter B. The ratio of B to H expresses the permeability of the material. The usual symbol for permeability is the Greek letter μ. So we may say that B is equal to μ times H. For example, a certain specimen of iron, when subjected to a magnetic force capable of creating, in air, 50 magnetic lines to the square centimetre, was found to be permeated by no fewer than 16,062 magnetic lines per square centimetre. Dividing the latter figure by the former, gives as the value of the permeability at this stage of the magnetisation 321, or the permeability of the iron is 321 times that of air. The permeability of such non-magnetic materials as silk, cotton, and other insulators, also of brass, copper, and all the non-magnetic metals is taken as 1, being practically the same as that of the air.

This mode of expressing the facts is, however, complicated by the fact of the tendency in all kinds of iron to magnetic saturation. In all kinds of iron the magnetisability of the material becomes diminished as the actual magnetisation is pushed further. In other words, when a piece of iron has been magnetised up to a certain degree it becomes, from that degree onward, less permeable to further magnetisation, and though actual saturation is never reached, there is a practical limit beyond which the magnetisation cannot well be pushed. Joule was one of the first

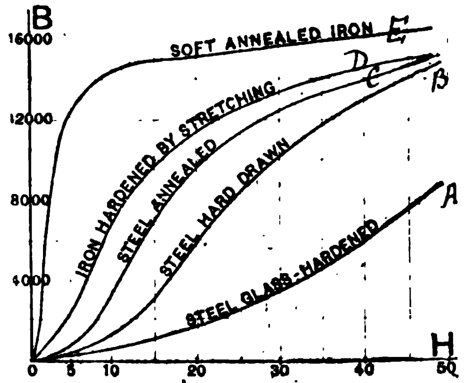


FIG. 14.—Curves of Magnetisation of Different Magnetic Materials.

to establish this tendency toward magnetic saturation. Modern researches have shown numerically how the permeability diminishes as the magnetisation is pushed to higher stages. The practical limit of the magnetisation, B, in good wrought iron is about 20,000 magnetic lines to the square centimetre, or about 125,000 lines to the square inch; and in cast iron the practical saturation limit is nearly 12,000 lines per square centimetre, or about 70,000 lines per square inch. In designing electromagnets, before calculations can be made as to the size of a piece of iron required for the core of a magnet for any particular purpose, it is necessary to know the magnetic properties of that piece of iron; for it is obvious that the iron be of inferior magnetic permeability, a larger piece of it will be required in order to produce the same magnetic effect as might be produced with a smaller piece of higher permeability. Or, again, the piece having inferior permeability will require to have more copper wire wound on it; for in order to bring up its magnetisation to the required point, it must be subjected to higher magnetising forces than would be necessary if a piece of higher permeability had been selected.

A convenient mode of studying the magnetic facts respecting any particular brand of iron is to plot on a diagram the curve of magnetisation—*i.e.*, the curve in which the values, plotted horizontally, represent the magnetic force, H, and the values plotted vertically those that correspond to the respective magnetisation, B. In Fig. 14, which is modified from the researches of Prof. Ewing, are given five curves relating to soft iron, hardened iron, annealed steel, hard-drawn steel, and glass-hard steel. It will be noticed that all these curves have the same general form. For small values of H the values of B are small, and as H is increased B increases also. Further, the curve rises very suddenly, at least with all the softer sorts of iron, and then bends over and becomes nearly horizontal. When the magnetisation is in the stage below the bend of the curve, the iron is said to be far from the state of saturation. But when the magnetisation has been pushed beyond the bend of the curve, the iron is said to be in the stage approaching saturation; because at this stage of magnetisation it requires a large increase in the magnetising force to produce even a very small increase in the magnetisation. It will be noted that for soft wrought iron the stage of approaching saturation sets in when B has attained the value of about 16,000 lines per square centimetre, or when H has been raised to the value of about 50. As we shall see, it is not economical to push B beyond this limit; or, in other words, it does not pay to use stronger magnetic forces than those of about H = 50.

METHODS OF MEASURING PERMEABILITY.

There are four sorts of experimental methods of measuring permeability.

1. *Magnetometric Methods.*—These are due to Müller, and consist in surrounding a bar of the iron in question by a magnetising coil, and observing the deflection its magnetisation produces in a magnetometer.

2. *Balance Methods.*—These methods are a variety of the preceding, a compensating magnet being employed to balance the effect produced by the magnetised iron on the magnetometric needle. Von Feilitzsch used this method, and it has received a more definite application in the magnetic balance of Prof. Hughes. The actual balance is exhibited to-night upon the table, and I have beside me a large number of observations made by students of the Technical College by its means, upon sundry samples of iron and steel. None of these methods are, however, to be compared with those that follow.

3. *Inductive Methods.*—There are several varieties of these, but all depend on the generation of a transient induction-current in an exploring coil which surrounds the specimen of iron, the integral current being proportional to the number of magnetic lines introduced into, or withdrawn from, the circuit of the exploring coil. Three varieties may be mentioned.

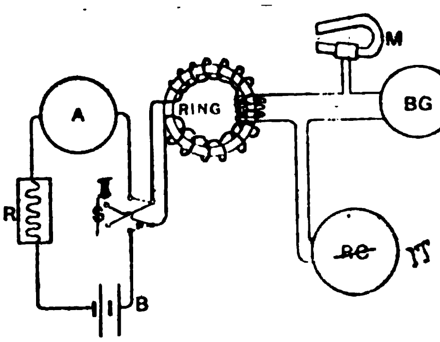


FIG. 15.—Ring Method of Measuring Permeability (Rowland's Arrangement).

(*A*) *Ring Method.*—In this method, due to Kirchhoff, the iron under examination is made up into a ring, which is wound with a primary, or exciting coil, and with a secondary, or exploring coil. Determinations on this plan have been made by Stowletow, Rowland, Bosanquet, and Ewing; also by Hopkinson. Rowland's arrangement of the experiment is shown in Fig. 15, in which B is the exciting battery, S the switch for turning on or reversing the current, R an adjustable resistance, A an ampere-meter, and BG the ballistic galvanometer, the first swing of which measures the integral induced current. RC is an earth inductor or reversing coil wherewith to calibrate the readings of the galvanometer, and above is an arrangement of a coil and a magnet to assist in bringing the swinging needle to rest between the observations. The exciting coil and the exploring coil are both wound upon the ring; the former is distinguished by being drawn with a thicker line. The usual mode of procedure is to begin with a feeble exciting current, which is suddenly reversed, and then reversed back. The current is then increased, reversed, and re-reversed, and so on, until the strongest available points are reach. The values of the magnetising force, H, are calculated from the observed value of the current by the following rule. If the strength of the current, as measured by the ampere-meter, be i, the number of spires of the exciting coil S, and the length in centimetres of the coil—*i.e.*, the mean circumference of the ring—be l, then H is given by the formula

$$H = \frac{4\pi}{10} \times \frac{S\,i}{l} = 1{\cdot}2566 \times \frac{S\,i}{l}$$

Bosanquet, applying this method to a number of iron rings, obtained some important results. In Fig. 16 are plotted out the values of H and B for seven rings. One of these, marked J, was of cast steel, and was examined both when soft and afterwards when hardened. Another, marked I, was of the best Lowmoor iron. Five were of Crown iron of different sizes. They were marked for distinction with the letters G, E, F, H, K. In the accompanying Table A are set down the values of B at different stages of the magnetisation.

I have the means here of illustrating the induction method of measuring permeability. Here is an iron ring, having a cross-section of almost exactly one square centimetre. It is wound with an exciting coil supplied with current by two accumulator cells;

* The following are the various ways of expressing the three quantities under consideration:

B.—The internal magnetisation. The magnetic induction. The induction. The intensity of the induction. The permeation. The number of lines per square centimetre in the material.

H.—The magnetising force at a point. The magnetic force at a point. The intensity of the magnetic force. The number of lines per square centimetre that there would be in air.

μ.—The magnetic permeability. The permeability. The specific conductivity for magnetic lines. The magnetic multiplying power of the material.

TABLE A.—VALUES OF B IN FIVE CROWN IRON RINGS.

Name.	G.	E.	F.	H.	K.
Mean diam.	21·5 cm.	10·035 cm.	22·1 cm.	10·735 cm.	22,725 cm.
Bar thickn'ss	2·535	1·298	1·292	0·7137	0·7544
Mag. force					
0·2	126	73	62	82	85
0·5	377	270	224	208	214
1	1,449	1,293	840	675	885
2	4,564	3,952	3,533	2,777	2,417
5	9,990	9,147	8,293	8,479	8,884
10	13,023	13,357	12,540	11,376	11,388
20	14,911	14,653	14,710	14,066	13,273
50	16,217	15,704	16,062	15,174	13,880
100	17,148	16,677	17,900	16,134	14,837

over it is also wound an exploring coil of 100 turns connected in circuit (as in Rowland's arrangement) with a ballistic galvanometer which reflects a spot of light upon yonder screen. In the circuit of the galvanometer is also included a reversing earth-coil. As a matter of fact, this earth-coil is of such a size, and wound with so many convolutions of wire, that when it is turned over, the amount of cutting of magnetic lines is equal to 840,000, or is the same as if 840,000 magnetic lines had been cut once. By adjusting the resistance of the galvanometer circuit, it is arranged that the first swing due to the induced current when I suddenly turn over the earth-coil is 8·4 scale divisions. Then, seeing that

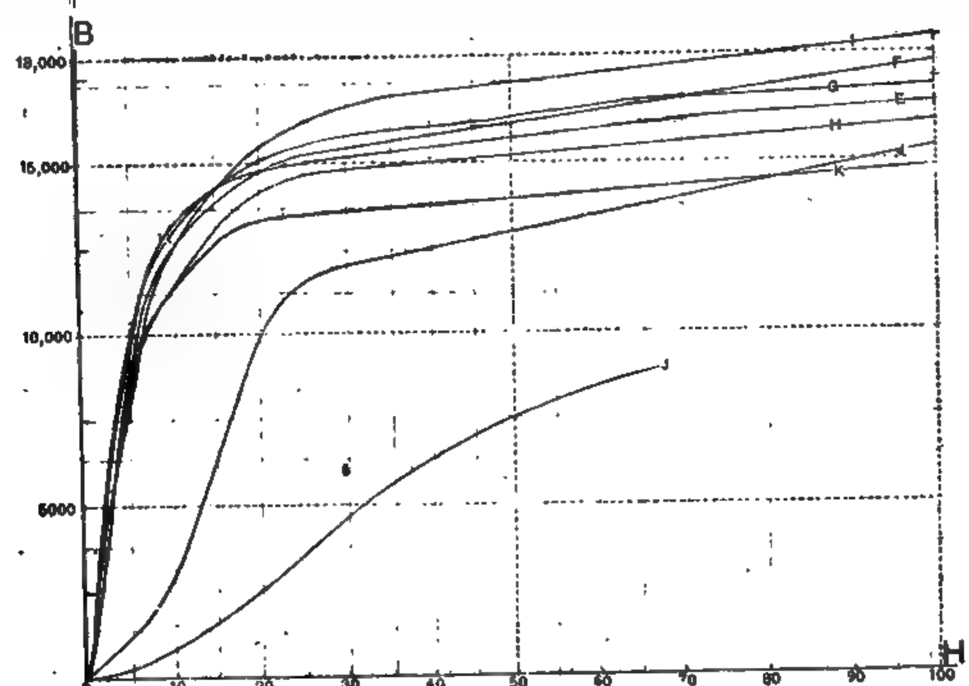


FIG. 16.—Bosanquet's Data of Magnetic Properties of Iron and Steel Rings.

our exploring coil has 100 turns, it follows that when in our subsequent experiment with the ring we get an induced current from it, each division of the scale over which the spot swings will mean 1,000 lines in the iron. I turn on my exciting current. See: it swings about 11 divisions. On breaking the circuit it swings nearly 11 divisions the other way. That means that the magnetising force carries the magnetisation of the iron up to 11,000 lines; or, as the cross-section is about one square centimetre, B = 11,000. Now, how much is H? The exciting coil has 180 windings, and the exciting current through the amperemeter is just one ampere. The total excitation is just 180 "ampere-turns." We must, according to our rule given above, multiply this by 1·2566 and divide by the mean circumferential length of the coil, which is about 32 centimetres. This makes H = 7. So if B = 11,000 and H = 7, the permeability (which is the ratio of them) is about 1,570. It is a rough and hasty experiment, but it illustrates the method.

Bosanquet's experiments settle the debated question whether the outer layers of an iron core shield the inner layers from the influence of magnetising forces. Were this the case, the rings made from thin bar iron should exhibit higher values of B than do the thicker rings. This is not so; for the thickest ring, G, shows throughout the highest magnetisations.

(*B*) *Bar Method.*—This method consists in employing a long bar of iron instead of a ring. It is covered from end to end with the exciting coil, but the exploring coil consists of but a few turns of wire situated just over the middle part of the bar. Rowland, Bosanquet, and Ewing have all employed this variety of method; and Ewing specially used bars the length of which was more than 100 times their diameter, in order to get rid of errors arising from end-effects.

(*C*) *Divided Bar Method.*—This method, due to Dr. Hopkinson, is illustrated by Fig. 17.

The apparatus consists of a block of annealed wrought iron about 18in. long, 6½in. wide, 2in. deep, out of the middle of which is cut out a rectangular space to receive the magnetising coils.

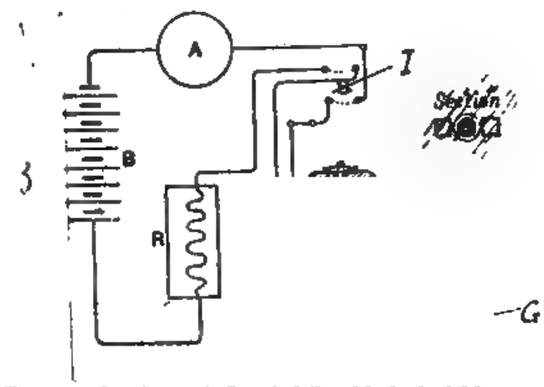


FIG. 17.—Hopkinson's Divided Bar Method of Measuring Magnetic Permeability.

The test samples of iron consist of two rods, each 12·65 millimetres in diameter, turned carefully true, and slide in through holes bored in the ends of the iron blocks. These two rods meet in the middle, their ends being faced true so as to make a good contact. One of them is secured firmly, and the other has a handle fixed to it, by means of which it can be withdrawn. The two large magnetising coils do not meet, a space being left between them. Into this space is introduced the little exploring coil, wound upon an ivory bobbin, through the eye of which passes the end of the movable rod. The exploring coil is connected to the ballistic galvanometer, B G, and is attached to an

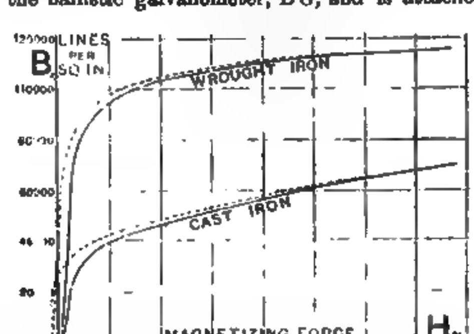


FIG. 18.—Curves of Magnetisation of Iron.

indiarubber spring (not shown in the figure), which, when the rod is suddenly pulled back, causes it to leap entirely out of the magnetic field. The exploring coil had 350 turns of fine wire; the two magnetising coils had 2,008 effective turns. The magnetising current, generated by a battery, B, of eight Grove cells, was regulated by a variable liquid resistance, R, and by a shunt resistance. A reversing switch and an ampere-meter, A, were included in the magnetising circuit. By means of this appa-

ratus the sample rods to be experimented upon could be submitted to any magnetising forces, small or large, and the actual magnetic condition could be examined at any time by breaking the circuit and simultaneously withdrawing the movable rod. This apparatus, therefore, permitted the observation separately of a series of increasing (or decreasing) magnetisations without any intermediate reversals of the the entire current. Thirty-five samples of various irons of known chemical composition were examined by Hopkinson, the two most important for present purposes being an annealed wrought iron and a grey cast iron, such as are used by Messrs. Mather and Platt in the construction of dynamo machines. Hopkinson embodied his results in curves, from which it is possible to construct, for purposes of reference, numerical tables of sufficient accuracy to serve for future calculations. The curves of these two samples of iron are reproduced in Fig. 18, but with one simple modification. British engineers who unfortunately are condemned by local circumstances to use inch measures instead of the international metric system, prefer to have the magnetic facts also stated in terms of square inch units instead of square centimetre units. This change has been made in Fig. 18, and the symbols $B_{\prime\prime}$ and $H_{\prime\prime}$ are chosen to indicate the numbers of magnetic lines to the square inch in iron and in air respectively. The permeability or multiplying power of the iron is the same, of course, in either measure. In Table II. are given the corresponding data in square inch measure; and in Table III. the data in square centimetre measure for the specimens of iron.

TABLE II.—Square Inch Units.

Annealed Wrought Iron.			Grey Cast Iron.		
$B_{\prime\prime}$	μ	$H_{\prime\prime}$	B	μ	$H_{\prime\prime}$
30,000	4,650	6·5	25,000	763	32·7
40,000	3,877	10·3	30,000	756	39·7
50,000	3,031	16·5	40,000	258	155
60,000	2,159	27·8	50,000	114	439
70,000	1,921	36·4	60,000	74	807
80,000	1,409	56·8	70,000	40	1480
90,000	907	99·2	—	—	—
100,000	408	245	—	—	—
110,000	166	664	—	—	—
120,000	76	1581	—	—	—
130,000	35	3714	—	—	—
140,000	27	5185	—	—	—

TABLE III.—Square Centimetre Units.

Annealed Wrought Iron.			Grey Cast Iron.		
B	μ	H	B	μ	H
5,000	3,000	1·66	4,000	800	5
9,000	2,250	4	5,000	500	10
10,000	2,000	5	6,000	279	21·5
11,000	1,692	6·5	7,000	133	42
12,000	1,412	8·5	8,000	100	80
13,000	1,083	12	9,000	71	127
14,000	823	17	10,000	53	188
15,000	526	28·5	11,000	37	292
16,000	320	50	—	—	—
17,000	161	105	—	—	—
18,000	90	200	—	—	—
19,000	54	350	—	—	—
20,000	30	666	—	—	—

It will be noted that Hopkinson's curves are double, there being one curve for the ascending magnetisations, and a separate one, a little above the former, for descending magnetisations. This is a point of little importance in designing electromagnets. Iron, and particularly hard sorts of iron, and steel, after having been subjected to a high degree of magnetising force, are subsequently to a lesser magnetising force found to retain a higher degree of magnetisation than if the lower magnetising force had been simply applied. For example, reference to Fig. 18 shows that the wrought iron, where subjected to a magnetising force gradually rising from zero to $H_{\prime\prime} = 200$, exhibits a magnetisation of $B_{\prime\prime} = 95,000$; but after $H_{\prime\prime}$ has been carried up to over 1,000, and then reduced again to 200, $B_{\prime\prime}$ does not come down again to 95,000, but only to 98,000. Any sample of iron which showed great retentive qualities, or in which the descending curve differs widely from the ascending curve, would be unsuitable for constructing electromagnets, for it is important that there should be as little residual magnetism as possible in the cores. It will be noted that the curves for cast-iron show more of this residual effect than do those for wrought iron. The numerical data in Tables II. and III. are means between the ascending and descending values.

As an example of the use of the tables we may take the following: How strong must the magnetising force be in order to produce in wrought iron a magnetisation of 110,000 lines to the square inch? Reference to Table II. or to Fig. 18 shows that a magnetising field of 664 will be required, and that at this stage of the magnetisation the permeability of the iron is only 166. As there are 6·45 square centimetres to the square inch, 110,000 lines to the square inch correspond very nearly to 17,000 lines to the square centimetre; and $H_{\prime\prime} = 664$ corresponds very nearly to $H = 100$.

(To be continued.)

CABLE v. ELECTRICITY.

In a discussion on tramway working, Mr. Holroyd Smith writes:

The direct system of working street tramways by underground electric conductors is in appearance similar to a cable line, with the following differences:

The slit or opening in the road-surface does not exceed ⅝in., whilst for cables it is frequently 1¼in wide.

The electric channel or conduit only needs to be half the depth of a cable channel, and therefore does not interfere with gas and water-pipes, as is frequently the case with the cable system.

Instead of a running rope rattling over pulleys there is a stationary conductor.

Instead of a gripper, attached to the car and made to grasp or release the running cable, and liable to derangement, causing serious accidents and loss of life, there is a contact-making "plough" passing through the slit, lightly touching the enclosed electric conductor, and passing the current to the motor on the car. If any derangement occurs, the only consequence is the stoppage of the car.

The cable car can only go in one direction, at one speed, and starts with a sudden impulse.

The electric car can go in either direction, and starts with a gradual silent movement, and the rate of travel may be increased to any desired speed, thus enabling the cars to "catch up" if delayed through any cause, instead of blocking *en masse*, as is the case with the cable system.

A strong man is required to operate the gripping lever of the cable car; a boy can easily drive the electric car, and cause it to move forward or backward quickly or slowly at will.

The electric car can move slowly round a street corner, whereas the cable car is whirled round at the maximum speed—a most dangerous practice.

The electric car, being only 10cwt. heavier than an ordinary tramcar, can be easily removed from the track in case of need, the "collector," or "plough," being instantly detachable, not a permanent fixture like the cable grip.

The one advantage the cable car has over the electric car is that it can deal with hills, however steep—straight up, if need. The electric car can, however, mount any hill suitable for ordinary street traffic.

An electric car could easily mount a zigzag gradient that would be practically impossible with a cable.

When once the conductors are laid, electricity has the same practical efficiency as the cable in dealing with exceptionally heavy traffic, at a trifling increase to the ordinary working expenses.

The electric conduit system is much cheaper to construct and equip than the cable, much easier and cheaper to work, less costly in maintenance and repairs, and gives a percentage of efficiency for the power expended at the depot of more than three times that obtainable by cable haulage.

SIR WILLIAM THOMSON'S NEW ELECTRICITY METER.*

This instrument forms at once an indicator by which the strength of a current passing at any given instant can be read off on a scale, and a supply meter by which the amount of current which has passed through the meter during any given time is recorded on a train of counting wheels. The indicator consist of a light aluminium frame, free to turn about a horizontal axis, having at its top end a coil of fine copper wire, c, and at its lower extremity a train of counting wheels, ω. The frame is supported on knife-edges, and a current is conducted into and out of the fine wire coil by two spirals of fine copper wire, H. The resistance of this coil is about 30 ohms, and it is joined in series with an anti-inductive platinoid resistance, R, of 970 ohms. When the meter is in action a small current is kept passing through the circuit. The whole current to be measured is conducted through a fixed coil, C, of copper ribbon, which is placed with its plane parallel to the plane of the fine wire coil when the latter is in its zero position. A scale, S, divided to give readings in amperes, is attached to the indicator, on which the strength of the current passing through the fixed coil can be read off by means of an index fixed to the case of the instrument.

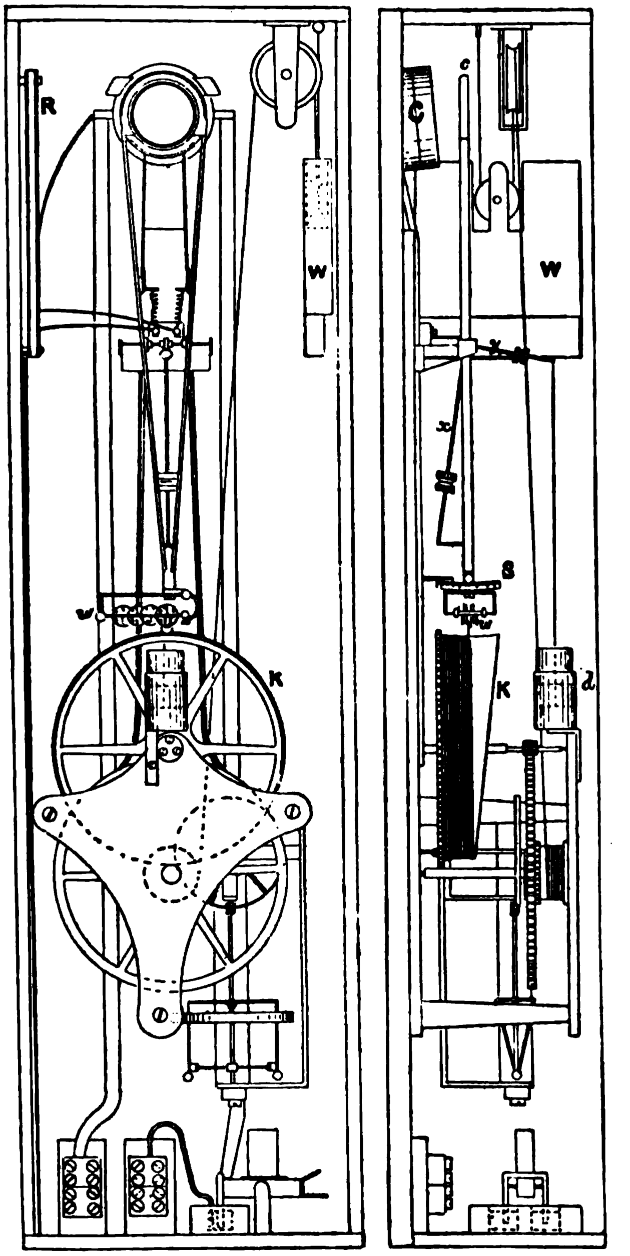
The recording apparatus consists of the train of counting wheels, W, mentioned above, and a revolving cam, K, driven by clockwork, which is kept in motion by a weight, W. The cam is kept revolving at a uniform rate, and, when a current is passing through the instrument, comes in contact at each revolution with a trailing wheel attached to the counting train, which it causes to turn round, and so makes a record.

The action of the meter may be shortly stated as follows: When no current is passing the indicator stands at O on the scale, S; the movable coil is about one millimetre from the fixed one, and the trailing wheel of the counter train is quite clear of the cam, so that no record can possibly be made. When a current is passing through the fixed coil the top end of the indicator is repelled *outwards*, and the counting train of wheels is

* Paper read before the British Association.

brought *inwards* towards the cam to a position depending upon the strength of current which can be read off on the scale. In this position, at the proper position of the revolution, the trailing wheel is lifted by the cam, and runs over a shorter or longer path in proportion to the strength of current. Thus, if the current passing through the fixed coil be five amperes, the counting wheels might record 20 for every revolution of the cam; whereas, were the current 10 amperes, the trailing wheel would roll over twice as long a path, and the record would be 40.

Two screwed rods are so attached to the indicator that one, x, is vertical, and the other, y, is horizontal when the beam is in its zero position. These rods are provided with adjustable nuts, those on the vertical being to adjust the sensibility of the instrument, while those on the horizontal rod are for the adjustment of the zero. By means of the former the constant of the



Front View. Side View.

meter can be quickly varied if found convenient. Thus a meter which is suitable for measurement from one to 20 lamps can be altered in a few minutes to suit ranges of from one to 50 or from one to 100 lamps. This adjustment can be made by an inspector without the use of any auxiliary instrument. All that has to be done is to hang on a weight of a given amount on the knife-edge stirrup at the end of the horizontal arm, and raise or lower the nuts on the vertical arm till the indicator shows a given reading on its scale. By this means also the constant of the meter can be checked at any time.

As at present arranged, the driving weight requires to be wound up periodically by means of a revolving disc on the front of the case. It is intended that this should be done by the consumer, and an arrangement is made by which the current is automatically cut off from the house when the weight is allowed to run down. Precautions are also taken to prevent any fraudulent tampering with the instrument.

ON THE SPECIFIC RESISTANCE OF COPPER.*

BY T. C. FITZPATRICK.

All the values given in tables for the specific resistance of the metals are directly or indirectly obtained from the values given by Matthiessen in his series of papers published in the *Transactions* of the Royal Society for the years 1860-64, and in the reports of the British Association for the same years.

In the *Transactions*† for the year 1860 is a paper by Matthiessen on the conductivity of pure copper and on the effects of impurities. No alloy of copper has as high a conductivity as the pure metal. His results are expressed in terms of the conductivity of a hard-drawn silver wire (100 at 0deg.). He gives the following values for samples of copper carefully prepared by himself:

(1)	93·00 at 18·6deg.	Giving a mean value of 93·08 at 18·9deg. as the conductivity of pure copper.
(2)	93·46 at 20·2deg.	
(3)	93·02 at 18·4deg.	
(4)	92·76 at 19·3deg.	
(5)	92·99 at 17·5deg.	

Numbers are given showing the effect on the conductivity of small quantities of oxide, and he states that he found it necessary to pass hydrogen through the molten metal for some time for entire reduction. In the *Transactions* for 1862 Dr. Matthiessen has a paper on the influence of temperature on the conductivity of metals. He again expresses his results in terms of a hard-drawn silver wire.

On page 8 will be found the results of his experiments on copper; the lowest temperature at which measurements were made was 12deg. or 16deg.; he there shows how the results for pure copper measured at 18deg. may be reduced to 0deg. C.; but no measurement was actually made at 0deg. for any of the metals experimented with.

He expresses the influence of temperature on a hard-drawn copper wire; the mean result of a number of determinations by the equation $\lambda = 100 - \cdot 38701\, t + \cdot 0009009\, t^2$
where 100 is the conductivity of copper at 0deg. C., so that a hard-drawn silver and copper wire have the same conductivity at 0deg. C.

The values obtained by comparison with a hard-drawn silver wire are then largely the source of the tables of specific resistances; but at the end of his appendix to the report of the Electrical Standards Committee for 1864 Matthiessen gives values for hard-drawn silver and copper wires in terms of the new B.A. unit; expressed as the resistance of a wire one metre long, weighing one gramme.

These values are:

Copper	·1469
Silver	·1682

The same table of values is given in the *Philosophical Magazine* for 1865, where also is given a table of specific resistances for wires one metre long and one millimetre diameter expressed in terms of the B.A. units, calculated from the value of the known conducting power of the gold-silver alloy in terms of hard-drawn silver, and also in terms of the B.A. unit.

The values thus obtained do not agree at all with the results calculated for the resistances of the gram-memetre by the specific gravities of the elements furnished by tables.

Thus

Silver	·02048	·02603
Copper	·02090	·02104

He states that he omitted to determine the specific gravity of the copper used in his experiments; he probably would not have obtained any very adequate results, and the weight of copper he used varied from 1·5 to 4 grammes.

The accuracy of Matthiessen's results seems to depend, therefore, on the accuracy of his determination of the resistance in terms of the B.A. unit of a hard-drawn silver wire; in considering, therefore, the question of the preparation of samples of copper of higher conductivities than Matthiessen obtained, it may be suggested that the cause of the difference is not the fact that Matthiessen did not prepare pure copper, but by the error in the value of the standard with which the comparison was made.

I have, therefore, made a series of experiments on the resistance of pure silver wires; and, as a general result, have obtained a value identical with that of Matthiessen; the difference is not due, therefore, to an error in the standard employed, as far as my experiments go.

Matthiessen does not give anywhere the details of his measurements of the specific resistances of the metals in terms of the B.A. unit; in the B.A. report he simply mentions that an approximate table is subjoined, not even stating the fact that the values are for a temperature of 0deg. C. I conclude, therefore, that these values are calculated out from the former, of which an account is given in the same B.A. report, and which were performed at a temperature of 20deg. C.

I have, therefore, on this account, as well as for other reasons stated later, made my measurements at the temperature of the air, and believe that as his values were reduced by a temperature coefficient to values at 0deg. C., I shall, by using the same temperature coefficient, and raising his value to near that for 20deg. C., obtain results directly comparable with Matthiessen's direct measurements.

For the measurement of the resistance of the specimens of wire a Wheatstone's bridge arrangement was employed, two of the arms

* Paper presented to the British Association by the Committee on Electrical Standards.

† Phil. *Transactions*, 1860, p. 85.

of the bridge were formed by a 10 and 1 standard B.A. unit—namely (66 and G). These were so nearly 10 to 1 that they were taken to be in that ratio.

The third arm was one-third of a B.A. unit, and in the fourth arm was the wire to be measured. This was stretched on a flat board, and soldered at the ends to copper plates, to which connecting wires were also soldered. The length of wire used was generally a little less than two metres, and the wires were, approximately, No. 18 B.W.G. The board had scales screwed to it at the two ends. The board and wire were placed in a long bath made of zinc and filled with paraffin. Wires which were left in the bath for some days, and in more than one case several weeks, were not found to have been at all acted on by the oil.

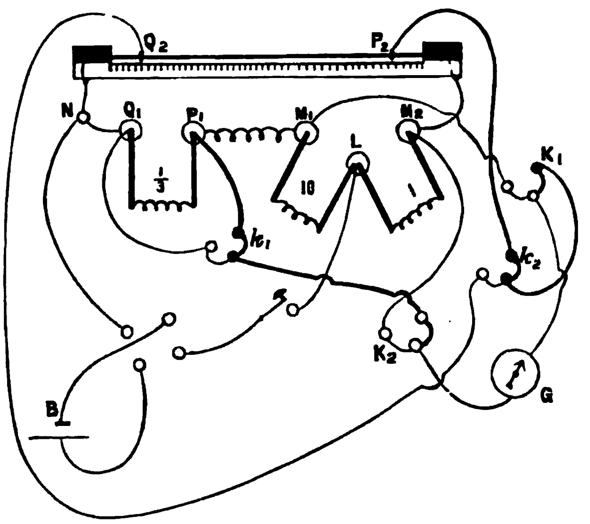


Fig. 1.

One end of the wire, P_2, Q_2, was connected by a binding screw through an adjustable resistance, r (½ metre of copper wire) to the mercury cup, Q_1, in which was one of the legs of the one-third coil, and also to a reversing key in the battery circuit.

The one-third and the 10 were connected up together through an adjustable resistance, P_1, M_1, one leg of each of the coils, 10 and 1, were in the same mercury cup, L, and the other end of the 1 B.A. unit was connected with the other end of the wire, P_2, Q_2.

A single Leclanché cell was connected up with the reversing key, and the fourth point of this key was connected with the mercury cup, L, into which the legs of 10 and 1 dipped. In this circuit there was also a touch key. The galvanometer circuit was always made, and thus there was no thermo-electric effect on meeting the galvanometer circuit. To each of the mercury cups, Q_1, P_1, M_1, M_2, were connected with separate binding screws two thick wires, one of which was welded to the copper plate at the bottom of the mercury cup. Each of these latter wires were connected with two way-keys, those in P_1 and Q_1 to the key k_1, those in M_1 to the key K_1, those in M_2 to the key K_2.

The base points of the keys K_1 and K_2 were connected with a delicate reflecting galvanometer, that employed for the comparison of the standards on the Fleming bridge. The base of the key k_1 was connected with the third point on the key K_2, and the third point, on the key K_1 was connected to the base point of a fourth key, k_2, the two other points on the key being connected with riders, with which contact can be made with two points on the wire, P_2, Q_2; the riders had straight edges, and thus their positions on the scales could be easily determined. In performing an experiment the keys K_1 K_2, and were so connected that the mercury cups, and so the ends of the coils, 10 and 1, were in circuit with the galvanometer. The resistance, R, P_1, M_1, was then varied till, on making the battery circuit, no deflection resulted. The ends of the 10 and 1 were then at the same potential, and as the other ends of these coils were connected with the same pole of the battery, there was the same fall of potential on the two lines.

The keys K_1 and K_2 were then reversed, and by the keys k_1 and k_2 one end of one-third coil and one point on the wire P_2, Q_2, were connected through the galvanometer, and afterwards the two other ends. The riders were adjusted till there was no deflection of the galvanometer. The length of wire between the two riders had a resistance of one-tenth that of the one-third B.A. unit coil.

By means of the series of keys it was easy to repeat the observations and to connect the ends of one-third coil with the wire. The resistance, R, did not often change during the experiments, as the room was at a constant temperature, any change in R only caused a shifting of the position of the riders. In each experiment, after all the adjustments, the bath was well stirred and everything left for half an hour. It was generally found that the riders did not require any adjustment. The battery was reversed and all the coils moved. The latter never caused any effect; sometimes the reversal of the battery caused a shifting of the two riders a millimetre or two in the same direction.

Another reading was taken three or four hours after. The coils one-third, 10, and one, were in water baths, and their temperature remained the same for hours together. The temperature of the paraffin bath, of course, was not so constant, it was kept well stirred in, and a thermometer reading to ·2deg. never showed any difference in the temperature at the different ends of the bath when the readings were taken. The thermometer employed was Kew corrected; and the corrections given were verified by recent comparison with a platinum thermometer by Mr. Griffiths.

Since the two standard coils employed were accurately in the ratio of 10 to 1, the accuracy in the resistance measurement depended entirely on the value of the 1/3 B.A. unit. This was first made as nearly as possible 1/3, but it was found that for the size of the wires measured (18 B.W.G.) this was too high a resistance. It had, therefore, to be reduced. For the determination of its value there was cut out in a block of paraffin wax a large central mercury cup, and outside this a circular channel. Thick copper plates were cut to fit them, and both were well amalgamated. By means of this cup arrangement the three B.A. units (H, G, and Flat) were connected up in multiple arc, and by means of stout copper rods the multiple arc arrangement was connected with the mercury cups with the Fleming's bridge, and so compared with the 1/3 B.A. unit, the temperature of the 1/3 being given. The following observations were taken:

July 12, 1889: 1/3, (18·4°)+986·6 (b.w.d.)=M.A+24·6 (b.w.d.)
July 22, 1889: 1/3, (17·4°)+966 (b.w.d.)=B.A.+24·1 (b.w.d.)
Aug. 26, 1890: 1/3 (16·8°)+986·1 (b.w.d.)=M.A.+23·9 (b.w.d.)

The value of a bridge wire division (b.w.d.) is ·0000498 B.A. units at 15deg., and the wire has a temperature coefficient of ·00143.

It is evident from these series of values that the 1/3 has not changed in resistance during the period of the experiments.

This comparison, however, introduced a possible error, as the temperature of the bridge wire at the time of experiment was not accurately known, and this is important when nearly the whole of the bridge wire is employed. To eliminate this possible error the 1/3 was compared with four B.A. units in multiple arc. In this case a large number of bridge wire divisions had to be subtracted from the value of the 1/3, and the whole number of bridge wire divisions entering into the calculation for the values of the 1/3 was largely reduced. The four coils in multiple arc were (F, G, H, and Flat):

Aug. 25, 1890: 1/3, 16·8°+157 (b.w.d.)=M.A.+852·05 (b.w.d.)
Aug. 26, 1890: 1/3, 16·8°+157·5 (b.w.d.)=B.A.+851·9 (b.w.d.)

All the four coils were at the same temperature (16·8). These values are taken from the B.A. Report, 1888.

Flat	1·000448
F	1·000028
G	·99955
H	·99969

These give for the two multiple arc arrangements the values ·33330 and ·24998. The connecting rods had a resistance of ·00042, and these gave for the value of the 1/3 at 16·8deg. ·28537. The temperature coefficient for the coil is ·0001 per 1deg. C.

To measure the lengths of the wires two microscopes with scales and verniers reading to ·1 of a millimetre were set up and firmly clamped in position; the distance between them was determined by means of the beam compass and the aid of a third microscope; the distance between this and the other two being directly read off on the beam compass for set positions of the verniers. The wires were cut with a fine fret saw at the points corresponding to the position of the riders in the resistance measurements. Before weighing the wires were carefully cleaned with methylated spirits, the balance employed was the one used by Mr. Glazebrook for our determination of the specific resistance of mercury, the weights were balanced against one another, and in all cases double weighings were taken.

The specific gravity of most of the wires was measured. For this purpose distilled water was boiled and cooled rapidly, the coil of wire immersed, and the beaker and its contents placed under the receiver of an air pump, which was connected up with a water pump. This was left running for two or three hours till all air bubbles had disappeared, the weight of the wire in water was determined, and a second reading taken some hours later. As the weight of wire used was from 16 to 20 grammes, fairly accurate values for the specific gravity of the several wires ought to have been obtained, and thus the value for each wire in terms of the B.A. unit for the resistance to conduction between the opposite faces of a cube of the material was found.

The first object of these experiments was to test directly in comparison with the B.A. standards samples of copper wire of high conductivities, with the view of comparing them with Matthiessen's standard. Application was therefore made to several firms for high-conductivity copper wires, for which my thanks are due to those who sent samples.

A table of results is subjoined, the results for all the specimens tested are given, and they show the variation in resistance of high-conductivity wires. (*See* Table A.)

IV. and IV′. are the same copper, but IV. is hard drawn, IV′. is annealed; they were measured just as they were sent from the manufacturers; the same is true of V. and V′., VI. and VI′.

It will be noticed that VI. and VI′., which are of considerably less resistance than the other wires, are of higher specific gravity; the firm that sent them thus wrote of them: "It is only occasionally we come across copper as high as this or high enough to be called the highest (in conductivity) we can produce. This copper has been produced electrolytically by our ordinary process." How this copper was treated after electro-deposition I do not know. I am inclined to think, from my own experience, that this difference in density is due rather to the condition of the copper than to its relative purity. Matthiessen found that very small quantities of impurities reduced the conductivity 20 or 30 per cent. and a sufficient amount of impurities to cause this decrease in density from 8·94 to 8·90, must make a larger increase in the resistance of the copper.

In his paper in the *Philosophical Magazine* above referred to Matthiessen gives us the value for hard-drawn copper in these terms as ·02104 B.A.

From his value for the gramme-metre, using the sp. gravity 8·95 given by tables, the same quantity was calculated but gave the result ·0209; in a note added, he states that he had used the sp. gravity 8·91, his results would have been more nearly alike; but a sp. gravity 8·90, I find, would give an almost identical value.

This would show, then, that Matthiessen's own table calculated for values obtained by comparison with hard-drawn silver is accurate. I have tested silver wires, but have not had time to draw up the results in tabular form; and I obtained an almost identical value for hard-drawn silver wire, as supplied me from Messrs. Johnson and Matthey, as is given by Matthiessen for the resistance of a gramme per metre.

It will be observed that wires IX. have the specific gravity 8·90, and give a value in terms of B.A. units for a cubic centimetre of the material identical with Matthiessen's value; this value is not given directly by Matthiessen, but is calculated from his results by Fleming Jenkin and given in his table in his book "Electricity and Magnetism"; it is 1,652. I have calculated it from Matthiessen's value given in the *Philosophical Magazine*, and get the number 1,653. Using the same temperature coefficient as before, the resistance of a cubic centimetre of hard-drawn copper is 1766·6.

On comparing the values for wires IX., X., and XI. in these terms, the results do not agree so well together as when expressed in terms of the gramme-metre. There is a corresponding difference in the values of the specific gravities; these latter have been very carefully determined, repeated with the results given.

Wires, therefore, of the same resistance expressed for grammes per metre may give a very different result when expressed as per cubic centimetre. M. Roux, of Paris, in a letter, gives the following table for high-conductivity wire from a paper of M. Hospitalier in *L'Electricité*, 1887; this paper I have, unfortunately, not been been able to see.

Density	8·897	9·32	9·6
Conductivity equal volume.........	102·4	106·7	110·8
Conductivity equal weight	101·7	101·2	101·6

What is 100 in the conductivity units is not expressed. M. Roux thinks that the former is the more rational method of expressing the result, *i.e.*, for one of equal volume.

Matthiessen expressed all his results in terms of equal weight, justifying it by the greater accuracy obtainable when working with small weights of wire. Small errors in the value of the specific gravity are easily made, and cause a similar error in the result for equal volumes of different wires; unless working with long lengths of thick wire the weight of the wire is small, and the weight of the water displaced cannot be determined within ·5 to 1 milligramme, and that only with care; this error in ·5 of a gramme means only an accuracy of 1 in 500. The values given in my table are probably correct to 1 in 1,500 or 1 in 2,000, as the weight of water displaced was in all cases over two grammes. Results, therefore, for resistances of wires of equal weight are the most trustworthy and, I think, also the most satisfactory if used to express the resistance of a material and not of any given wire.

Wires X. (1) and X. (2) are of the same copper, but drawn down separately X. (1) was beginning to fray, and another specimen of the same copper drawn down still further had on this account to be rejected; this has affected the resistance value expressed in both ways. Thus

X. (1)	·1573	1767
X. (2)	1569	1751

but much more so when expressed for equal volumes. In both the copper is of the same quality.

It will be noticed that with increase of specific gravity there is a decrease of resistance, even when the results are expressed for wires of equal weight; the resistance diminishes, therefore, more rapidly than the density increases. Wires, therefore, of the same quality may, in consequence of a difference in drawing, have a different density, and so the results expressed in terms of equal volume will differ considerably; while those for equal weight are the same, or approximately so.

The values obtained for IX., X., and XI. are so nearly identical, that it is not unfair to conclude that they are samples of pure copper; their value is identical with that obtained by Matthiessen at, I believe, the same temperature. The greater difference obtained at 0deg. C. between Matthiessen's value and samples of copper tested now at that temperature, is probably due to the fact that Matthiessen's value was not determined at 0deg., but reduced in value for that temperature from observations, as stated above, at about 20deg. C.

The higher conductivity or less resistance for the two samples given in the table is due not to increased purity in the preparation of the copper, but in the difference in the process of preparation, whereby a sample of greater density is obtained than results from the working up of small quantities of copper in the laboratory.

A sample of copper has been prepared by chemical means with the help of my friend, Mr. Skinner, but has not yet been measured.

Brazilian Submarine Telegraph Company.—The Directors of this Company recommend a final dividend of 3s. per share and a bonus of 3s. per share, making a total distribution of 7½ per cent. for the year ended June 30. The reserve fund is to be increased by £40,000, carrying forward £2,416. The receipts for the week ended October 3 amounted to £5,323.

COMPANIES' REPORTS.

WOODHOUSE AND RAWSON UNITED, LIMITED.

Directors: The Right Hon. Lord Aberdare, P.C., G.C.B., chairman; Sir Rawson W. Rawson, K.C.M.G., C.B., vice-chairman; Sir John Stokes, K.C.B.; Sir F. Leopold McClintock, F.R.S.; Samuel Pope, Esq., Q.C.; Frederick L. Rawson, Esq., managing director.

Annual report of the Directors to be presented to the shareholders at the general meeting to be held at Winchester House, Old Broad-street, E.C. on the 10th inst., at 12 o'clock.

Of the original capital all the ordinary and preference shares have now been issued. Of the ordinary shares one-half of their value remains uncalled. The premiums from the second issue, amounting to £4,050. 5s., have been placed to a reserve fund. From the balance-sheet it will be seen that after payment of all expenses and writing off £7,421. 16s. 9d. in reduction of the sum standing to patent account, the balance to the credit of the Company amounts to £61,085. 1s. 9d. Out of this sum the Directors propose to pay a dividend at the rate of 15 per cent. per annum on the ordinary shares and of 8 per cent. per annum on the preference shares, which together with the interim dividend for the half-year already paid at these rates, amounts to £18,749. 6s. 6d. Of the balance, amounting to £42,335. 15s. 3d., the Directors propose to place to reserve £25,000, of which £10,000 will be set aside to a goodwill reserve fund and £15,000 to a general reserve fund, and to apply £1,000 to the formation of an employés' pension fund, leaving £16,335. 15s. 3d. to be carried forward to next year's account. The Directors do not propose to increase the dividend anticipated in the prospectus, as the prudence of building up reserve funds of a considerable amount will be evident to the shareholders. The Directors think it well on this occasion to give more information than is usually contained in an annual report, in order to enable the shareholders to realise the scope and extent of the operations in which the Company is engaged. Their efforts during the past year have been directed to consolidating and extending the several branches of business which have been taken over by the Company. These are of a very comprehensive character, and include the manufacture of all articles connected with electricity and engineering, so far as they come reasonably within the technical and financial resources of the Company; the supply of all articles connected with electricity and electrical engineering; the execution of all works of installation coming within the province of electrical engineers and contractors; the testing and proving of new patents and inventions connected with electrical and engineering science, and their introduction to the public, either by arrangements for working such inventions by this Company or by assisting the owners in forming separate companies for working them. The experience of the past year leaves no doubt that great services may be rendered to the shareholders and to the public by developing this latter branch of the business, with prudence and energy; and the knowledge acquired from an extensive range of manufactures, and a thorough acquaintance with the demand and channels of supply of electrical plant and apparatus, place this Company in an exceptional position to invite and secure the confidence of inventors, and to assist them in bringing their inventions before the public With this object it is necessary to command the ready means of practically testing every kind of electrical and mechanical invention which may be offered, and to maintain an extensive business and correspondence in all parts of the world. The following are the factories owned by the Company and the character of the work done: (*a.*) West Kensington Hall Works, Hammersmith-road, W. These works, over an acre in extent, are the Company's freehold. Here are manufactured light goods, such as switches, lamps, measuring and other electrical instruments, primary and secondary batteries, and every class of small automatic machinery. Here also is carried on the electroplating business and manufacture of plating plant. At these works most processes offered to the Company are tested, and only when they have thoroughly passed the examination of the Company's experts is the purchase or introduction to the public entertained. At the present moment four important electrical inventions of exceptional merit are undergoing the process of final testing. (*b.*) Union Foundry, Kidsgrove, near Crewe. These works, which are also freehold, have been recently acquired on advantageous terms, and are well situated in the heart of the coal and iron district, having both a railway siding and a canal adjoining. They are fitted up with every class of heavy machinery to enable the Company to construct engines and boilers of almost any size or power, water and gas works plant, steam and hydraulic cranes, tanks, pumps, large dynamos and other machinery, whilst further special plant is now being erected to keep abreast of recent improvements. (*c.*) Cornbrook Telegraph Works, Manchester. These works are leasehold, and are fully engaged in the manufacture of telegraphic instruments; there are also manufactured small dynamos and motors, as well as light lathes and drilling, shaping, milling and screwing machines, specially designed for electrical work. Practically the whole of the contracts for telegraphic instruments, etc., for the London and North-Western Railway for a period of two years, together with contracts for the Caledonian and Great Eastern Railway Companies, have been placed with the Company at these works. (*d.*) The supply department is rapidly increasing its turnover. Its catalogue of electrical goods and appliances connected therewith is recognised as the most complete and comprehensive of its kind, and forms a standard text-book in the trade. The acquisition of the new warehouse, with entrance at 30, Cannon-street, and more recently of the lease of the neighbouring

		£	s.	d.
Proposed dividend for the second half-year at the rate of 8 per cent. per annum on the preference shares and 15 per cent. per annum on the ordinary shares		12,576	0	11
To general reserve fund	£15,000 0 0			
To goodwill reserve fund	10,000 0 0			
		25,000	0	0
To employés' pension fund		1,000	0	0
Carried forward to new profit and loss account		16,335	15	3
		£61,085	1	9
Net profit as per profit and loss account		61,085	1	9
		£61,085	1	9

NEW COMPANIES REGISTERED.

Electro-metallurgical Company, Limited.—Registered by T. H. Philpots, Rolls-chambers, 89, Chancery-lane, with a capital of £2,500 in £5 shares. Object: to acquire the business of the Electro-metallurgical Company, now carried on at 23, Newhall-hill, Birmingham, and the Victoria Plating Company, carried on at 9 and 10, Sherbourne-road, Bolsall-heath, Birmingham. The regulations of Table A mainly apply.

Leeds and London Electrical Engineering Company, Limited. Registered by Wilson, Bristowe, and Carpmael, 1, Copthall-buildings, E.C., with a capital of £100,000 in £5 shares. Object: to form centres in any towns and districts in the United Kingdom or elsewhere, at which electrical energy may be generated and accumulated, and from which the same may be distributed. The first subscribers are:

	Shares.
H. Linklater, 5, Benthal-road, N.	1
T. B. Arundell, 1, Devonshire-street, Portland-place, W.	1
P. H. Clark, 51, Norroy-road, Putney	1
J. Whitehead, Heycot, Crouch End	1
J. A. Roxburgh, 77, Queen's-road, Finsbury Park	1
G. K. Chambers, 10, Richmond-villas, Holloway	1
G. W. S. Hawes, 25, Colebrook-row, N.	1

There shall not be less than three nor more than seven Directors; the first to be appointed by the subscribers to the memorandum of association. Qualification: £500. Remuneration: One-tenth of net profits after 7 per cent. dividend, with the proviso that the same shall not exceed £1,500 divisible.

PROVISIONAL PATENTS, 1890.

SEPTEMBER 29.

15401. **Improvements in electrical switches.** Alfred Louis Sax and Charles William Sax, 47, Lincoln's-inn-fields, London.

15413. **An arc electric lamp.** Thomas Barnet Grant, 28, Southampton-buildings, London.

SEPTEMBER 30.

15455. **Improvements in or appertaining to welding metals electrically.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles L. Coffin, United States. (Complete specification.)

15456. **Improvements in or appertaining to welding metals electrically.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles L. Coffin, United States.) (Complete specification.)

15464. **Apparatus for governing electric light engines, marine engines, and other engines.** Timothy Sullivan, John William Hughes, Victor William Chemery, and Arthur Henry Spence Browne, 77, Chancery-lane, London.

15469. **Improved method of, and apparatus for, administering electricity to the human body.** Oliver Imray, 28, Southampton-buildings, London. (The Bethel Electric Medical Baths Company, Limited, Australia.) (Complete specification)

15482. **Improvements in and relating to electric batteries.** Henry Harris Lake, 45, Southampton-buildings, London. (Crosby Electric Company, United States.) (Complete specification.)

OCTOBER 1.

15547. **Improvements in locked switches for electric current circuits.** John Abbott Iliffe and Francis Teague, 433, Strand, London.

OCTOBER 2.

15573. **An improved method and means of attaching and suspending electric and other fittings.** Frederick Jonathan Down, 82a, New Bond-street, London.

15629. **Improvements in telephone transmitters and induction coils to be used therewith, and for other purposes.** William Wheatley and Joseph Lewis, 53, Chancery-lane, London.

15634. **Improvements in instruments for measuring electric energy.** Jasper Wetter, 433, Strand, London. (Anne Marie Bernard de Montesaus de Balloze, France.)

15635. **Improvements in or relating to the method and means employed for commuting alternating currents of electricity, and distributing or storing the electrical energy so obtained.** Charles James Hall, 433, Strand, London.

15640. **Improvements in electric or secondary batteries.** Emmanuel Hancock and Augustus John Marquand, 24, Southampton-buildings, London.

15643. **Improvements in and connected with electric tramways or railways, and for working electrically propelled vehicles thereon.** Edward Hopkinson, 47, Lincoln's-inn-fields, London.

15644. **Improvements in electric clock-circuit-closing apparatus.** William Brown, Silcote, Claremont-road, Highgate, London.

OCTOBER 3.

15654. **Improvements in pull-down switches for walls or ceilings for electric light.** Charles Walter Cox and Frederick Robinson, 8, Strand-street, Liverpool.

15673. **Improvements in telephonic switching and signalling apparatus.** Harry Thomas Ogilvie Fraser, 47, Lincoln's-inn-fields, London.

SPECIFICATIONS PUBLISHED.

1886.

2470. **Electrical locomotion, etc.** Julien. (Second edition.) 2s.

1889.

14867. **Electrical conductors.** Imray (Walton). 11d.

17124. **Electric circuits.** Thompson (The Westinghouse Electric Company). 8d.

17274. **Electric switch.** Grimston (Jacob). 6d.

17694. **Electrical wattmeter.** Wilson. 8d.

1890.

6156. **Electrical switch.** Schultz. 6d.

8892. **Electrical conductors, etc.** Muirhead and Wright. 6d.

10076. **Electrical conductors.** Gould and Gottschalk. 6d.

10868. **Electricity meters.** De Pass (Marès). 8d.

11017. **Electric railways, etc.** Thompson (Lynch). 8d.

11699. **Obtaining chlorine, etc., by electricity.** Nahnsen. 4d.

12247. **Electric lamps.** Lake (Pyle). 8d.

CITY NOTES.

Direct Spanish Telegraph Company.—The receipts for September were £2,526, against £2,139.

West Coast of America Telegraph Company.—The receipts for the month of September amounted to £5,050.

West India and Panama Telegraph Company.—The estimated receipts for the half-month ended Sept. 30 were £2,405, against £2,218.

Eastern Extension Telegraph Company.—The receipts of this Company for September amounted to £43,938, against £40,418.

Great Northern Telegraph Company.—The receipts for September were £25,800, making, from January 1, a total of £206,800, against £203,200 and £202,600.

Eastern Telegraph Company.—The traffic receipts of this Company for September were £55,346, as against £51,881 for the same period of 1889, or an increase of £3,465.

Woodhouse and Rawson United, Limited.—The Directors recommend a dividend at the rate of 15 per cent. per annum, carrying £25,000 to reserve, leaving £16,000 undivided.

Reuter's Telegram Company, Limited.—The Directors have declared an interim dividend at the rate of 5 per cent. per annum for the half-year ended June 30, payable on the 11th instant.

Cuba Submarine Telegraph Company.—The estimated receipts of this Company for the month were £3,000, as compared with £2,372. The receipts for June, estimated at £3,300, realised £3,324.

Telephone Company of Austria, Limited.—This Company have declared the usual half-yearly dividend to the 30th ult. on the preference shares at the rate of 6 per cent. per annum, payable, tax free, at an early date.

Western and Brazilian Telegraph Company, Limited.—The receipts for the week ended October 3, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,163.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2½
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	

NOTES.

Edison Motor.—The Edison Company are bringing out a new series of electric motors, in which the Eickemeyer armature is adopted.

Breslau.—The central station for Breslau is so rapidly progressing, that hopes are entertained to inaugurate the plant in February, 1891.

Change of Address.—Prof. Ayrton has left his house in Upper Phillimore-gardens, and his present address is 7, Horbury-crescent, Notting Hill, W.

Pressburg.—We are informed that a syndicate is being formed in this town for the purpose of lighting by electricity public and private offices, the subscription list now being in circulation.

Lyric Theatre.—Mr. Horace Sedger has contracted with the St. James and Pall Mall Electric Light Company, Limited, for the supply of all the current required for lighting the Lyric Theatre.

Paisley.—The Town Council have, on the motion of Provost Johnston, seconded by Bailie Andrews, agreed to apply to the Board of Trade for a provisional order to supply electric lighting for private and public purposes within the burgh.

Old Students' Dinner.—It is hoped that all good Old Students will remember the annual dinner to-night. We understand the attendance is likely to be very good, and a capital musical programme has also been arranged. The time is 7 p.m., sharp; and place, the Holborn Restaurant.

Westinghouse Noiseless Car.—The electric car put in operation at Allegheny, Pennsylvania, by the Westinghouse Company, and significantly named by them the "Noiseless," is said to be earning golden opinions—and orders—by its ease of manipulation and comparative silence in working.

Hanover Square.—Before the St. George's, Hanover-square, Vestry, the surveyor said that in view of the fact that the electric lighting companies were tearing the foot and road ways up all over the parish, he should advise the Vestry not to proceed with any paving work during the present year.

Cologne.—The municipal, gas, water and electric committee of Cologne have decided to introduce electric light to a part of this town. The system adopted is that of Messrs. Ganz and Co., with alternate currents at 2,000 volts; the Calles mains, on Berthoud-Borel system, have been ordered of the works at Cortaillod, Switzerland.

Electric Fog Signals.—We see it stated that Messrs. Child and Emery are trying a system of electric fog signals somewhat similar to that we mentioned last week on the South-Eastern Railway shunting lines at Erith. An electric bell and a movable disc on the locomotive are worked by contact with an auxiliary contact rail when approaching the distance signals.

Telephonic Bonnets.—A new application of the telephone for military purposes is shortly to be introduced into the Italian fortress artillery; it consists of a so-called telephonic bonnet, to be worn by each officer being in charge of a gun, which will enable him to receive the instructions of the commander-in-chief or other, in the quickest possible time.

Lodi.—A small central station will be erected at Lodi, near Mailand, Germany, for the electric lighting of this town; the motive power is obtained by a Benallio turbine driving a Tecnomasio dynamo of 55 amperes and 150 volts. A separate accumulator sub-station with 60 cells is charged during the day, and this, together with the dynamo mentioned, supplies the current at night.

Personal.—Mr. Oswald Haes, who is an old student and assistant of Profs. Ayrton and Perry's, and has been on the engineering staff of the Brush Electrical Engineering Co. and its predecessor for three years, has been appointed to the management of the engineering department of the Company's branch in Australia, and is shortly proceeding to Sydney, N.S.W., to take up his position.

Nelson (Lancs.).—The Nelson Local Board have decided to lay an underground cable sufficient for an installation of 600 lights. Already shopkeepers have applied for 200 lights, and no difficulty is expected in obtaining applications for the remainder. The cost of gas in Nelson is 2s. 6d. per 1,000ft., and it is announced that the price of the electric light, with the same illuminating power as 1,000ft. of gas, will be equal to gas at 4s. 6d.

Sterilising Liquids.—M. de Meritens has patented two processes for sterilising liquids to prevent fermentation. This he does in one process by constituting the containing vessel as a Leyden jar, the liquid being the inner coating, the electrical effect being produced by means of condensers. Another and apparently less reasonable method consists in placing the vessel and its liquid to be sterilised in the field of a permanent or electro magnet.

Heilbronn.—The German Government has consented to the establishment of cable communication between Heilbronn and Lauffen for the transmission of light and power, under the conditions that the minimum height of the wires above ground be eight yards, the smallest diameter of the wire being 0·26in., and, further, that the wires be laid underground through the town, and the high tension be transformed in a special building into the usual low tension before entering the town.

Okonite.—The Okonite Company have taken permanent offices at the corner of Queen Victoria-street and Bread-street. Mr. H. B. Bourne, lately assistant with Prof. Ayrton, has been appointed technical adviser. The company are, we are told, building other premises alongside the present works of Messrs. Shaw and Conolly, which they have acquired, and new and special machinery for manufacture of okonite cable is coming over from their American works in Passaic, New Jersey.

Ferranti Mains.—The London Electric Supply Corporation have informed the Newington Vestry of their intention to commence the laying of electrical mains in Blackman-street, Newington-causeway, Newington-butts, and the Walworth-road. They have also informed the St. George's Vestry of their intention to lay mains in Westminster Bridge-road, Waterloo-road, and Borough High-street. The surveyor complained that a sewer had been damaged in one place, and the Vestry decided to claim damages.

City Windmills.—An innovation has been started in that dull thoroughfare, the City-road, which has the advantage both of picturesqueness and usefulness. This is a sky sign of a novel nature, consisting of a large American windmill, upon the premises of Messrs. Carwadine and Co., who by this means grind their oatmeal, pump their own water, and will probably supply motive power for their own electric light. Electrical engineers who wish to see what can be done with this type of motive power, could not do better than call here to investigate its capabilities.

Private Central Station in the City.—The largest private central installation yet erected will shortly be installed at the Billiter-street offices in the City. These buildings extend over a surface of four acres, and the installation will be of a capacity for 4,000 lights, with duplicate plant. The contract is being carried out by Messrs. Verity and Sons, Covent Garden. The plant will consist of compound engines and boilers with accumulators as reserve, and the orders for plant are already placed. The installation is to be ready for the coming winter season.

Electro-Deposition of Wrought Iron.—The New York *Engineering News* in a note states that the electro-deposition of wrought iron is a scheme on which Stephen H. Emmons, a Pittsburgh inventor, is engaged. The pig iron is placed in vats filled with a chemical solution and forms the negative pole. Thin sheet-iron plates suspended in the bath form the positive pole. The current of electricity is furnished by a dynamo, and it is stated that iron of chemical purity and remarkable toughness is deposited on the positive plates. Whether the invention can be made a commercial success does not yet appear.

Rival Manufacturers.—We are informed that some people are not quite certain as to who's who in regard to "The Telegraph Manufacturing Company" and "The Birmingham Telegraph Factory." The former is the older company, the latter being the works of Mr. Slater Lewis, who was formerly manager to the Telegraph Manufacturing Company. It is said that all is "fair in love and war," and as business competition savours somewhat of warfare, the old saying may by some be held to apply; but we think it would be more in the interest of a new firm, be it or be it not the result of a split with an older one, to make mistakes impossible.

Electric Light for Monmouth.—A special meeting of the Monmouth Town Council was held last Friday morning, when the deputation, consisting of the Mayor, Mr. Alderman Hyam, and the town clerk, reported that they had visited Fareham and inspected the recent installation of the electric light in that town, and were of opinion that the same was highly satisfactory, the town being lighted by 20 arc and 85 incandescent lamps at a considerable saving per annum as compared with gas supplied by meter. It was determined to at once draw up specifications for laying down an installation in this town, and to advertise for tenders.

Petroleum Engines for Lighting.—We have been expecting to hear of applications in country places of Priestman's petroleum engine, and it now appears that these prime motors are beginning to be somewhat extensively employed in places where gas or steam are out of the question. Messrs. Verity and Sons, we hear, are installing some four or five of these oil engines with great success. One of these, in the West of England, is a typical instance. A 5-h.p. nominal petroleum engine is used, driving a dynamo used, with accumulators, to supply a mansion with 120 incandescent lamps. We may expect to see more use made of this simple and ingenious engine.

Sale of Plant.—To those who wish to acquire some good second-hand plant for electric lighting, the chance arises from the intended sale of the machinery until now employed by the Westminster Electric Supply Corporation at their temporary station, Victoria-mansions, used for the lighting of the House of Commons. The machinery is of a modern type and nearly new. It is to be sold shortly by auction by Messrs. Wheatley Kirk, Price, and Goulty. The catalogue includes 2,000-volt alternators, compound-wound and shunt-wound dynamos, all by Goolden and Co., besides 16-h.p. Marshall's horizontal engines, shafting, instruments, and other effects.

Thomson-Houston Cars at Bremen.—The electric tram line on the Thomson-Houston overhead system installed at Bremen, has been so successful that a second line will be shortly carried out, having a length three times as great as the first. The work upon the present line was commenced on 22nd June, 1889. Since this time until the 25th September last, 453,491 paying passengers have been transported, and the cars have run a distance of 48,450 kilometres. There has been no interruption of service, due either to overhead construction or the electrical apparatus, and the telephone and telegraph service have not been found to suffer. The director of police in Bremen has given the company a certificate of its efficiency, good working, and safety to life and property in the crowded streets along which it runs.

City Lighting.—The third or western district of the City is not to be left without its electric lighting. The Commissioners of Sewers decided at their last meeting, without discussion, to agree to a report of the Streets Committee recommending that advertisements should be issued inviting tenders for lighting the western district of the City by electricity, on similar conditions to those arranged for the east and central districts, but intimating that should any deviation from such conditions, favourable to the Commissioners, be desired by the companies tendering, such deviations must be specifically set forth. It is almost unnecessary to remind our readers that the two latter districts are to be lighted respectively by Brush and by Thomson-Houston arc lamps, and the price to be obtained for each of these is £26 per arc lamp per annum.

Electric Lighting for Tramcars.—The experiment was tried last week of lighting a car belonging to the Bradford Tramways and Omnibus Company by electricity. The car selected was one of the one-horse cars running from Rawson-square to Manningham Park, and was illuminated with three incandescent lamps of five candle-power each. The light obtained was just about equivalent to that obtained under the best conditions by the oil lamps at present in use, but, of course, possessed the advantages of not giving off any smell or requiring to be trimmed. The lamps were fed from three E.P.S. accumulators placed beneath the seats, capable of supplying the current continuously for six hours. The experiment was carried out by Woodhouse and Rawson United, Limited, and it will be repeated as a trial during the week under the inspection of directors of the tramway company.

Bath.—The Electric Light Committee at the meeting of the Bath Surveying Committee last week, made a report (presented by Mr. Sturges) as to the progress of the light since its inauguration last June. The report stated it was for the Council to decide whether a specialist should now be appointed to examine the whole system, as was mentioned at the time of Major Cardew's visit. It also mentioned that there was some difference between the Board of Trade and the Authority as to the terms upon which the latter should have the right of purchase at the expiration of the contract. Mr. Sturges moved that the documents be printed for circulation among the members of the Authority. Mr. Bartrum seconded, and expressed regret that Mr. Massingham could not see his way to continue reflectors to the lamps, which in other places effected great improvement. The motion was carried.

Verity and Sons.—The rush of business in electrical work which has been felt during this autumn in England has greatly affected manufacturing interests, and amongst others Messrs. Verity and Sons have been obliged to extend their works. The two well-known firms bearing the name of Verity—B. Verity and Sons, of Covent Garden, and Verity Bros., of Regent-street—have amalgamated, though still for the present carrying on their businesses as before. The name, we suppose, may possibly be also amalgamated into Verity Bros. and Sons. Messrs. Verity have been so pressed in their London works that they have now taken large premises in Birmingham capable of providing work for 700 men, and Mr. J. B. Verity and Mr. Coles are at present organising the works, which are practically ready, and orders are already received, we understand, almost sufficient to keep it going. These facts speak well for the progress of electrical work for the coming season.

Edinburgh International Exhibition. — The Royal Scottish Society of Arts held a special session at the exhibition on October 13th, under the presidency of Lord Kingsburgh. Five papers were read, three of which were electrical—viz.: "On the Telegraphic Exhibits," by Prof. Grant-Ogilvie; "Telpherage and Electric Railways" (which appears in this issue), by Mr. E. Manville; and "Electrical Navigation," by Mr. A. R. Bennett. There was a large attendance of members. In moving a vote of thanks to the authors, Lord Kingsburgh regretted that the electrical industries had, so far, met with scant recognition in Scotland, and expressed a hope that the abundant water supplies in the Highlands would soon be turned to useful account in providing light and power to the various cities and towns. The members afterwards took trips on the telpherway and electric tramway and in the electric launches, and a special vote of thanks was accorded to Mr. Bennett, to whose initiation the meeting had been due.

Electric Construction Catalogue.—A handsome catalogue beautifully printed on superfine paper is issued by the Electric Construction Corporation to illustrate the combined E.P.S. and Elwell-Parker manufactures. Illustrations appear of the Elwell-Parker continuous and alternating current dynamos, and it seems rather a pity that some of these illustrations should appear to be inserted upside down. This is apparently due to the form of leaf adopted for distribution as separate sheets. The company make a speciality of electro-depositing machines, and lists are given of the numerous firms now using them. Switches of a strong and ample pattern are illustrated, and special notice is called to the fact that the E.P.S. ring contact switches and switchboards are reduced in price. We suppose most consumers would prefer to see such a statement made about E.P.S. cells, which of course come in prominently in the catalogue, but this does not seem to be considered their best policy just at present. Cell testers and automatic apparatus of the E.P.S. type are duly illustrated, and full and specific price lists are given of all the company's manufactures. These are all of such a standard nature that every electrical engineer should at once possess a copy of the new catalogue.

Shipley.—A deputation from the Shipley Tradesmen's Association waited upon the Shipley Local Board at their last meeting to urge the authority to take steps to secure better lighting of the principal streets, and to enquire into the possibility of adopting the electric light in the business thoroughfares. Mr. H. Smith pointed that Shipley was not so well lighted even as Bingley or Otley, while the price paid for gas was much higher in Shipley than in many other towns. Their association thought that the Board would not wish to be behind other towns. The chairman said he expected the cost of the electric light would be two or three times that of gas, while Bray's lamps, an extended use of which had been suggested, entailed a much greater outlay than ordinary lamps. The Board, however, was prepared to do all that was possible to improve the lighting of the town, but the deputation must bear in that they would have to help to pay any extra expense incurred. They could not expect Shipley to be like Bradford or Leeds. After some further remarks the deputation withdrew. No doubt better light will be the outcome of the deputation, and if electrical engineers wish it to be electric, they had better see that the Board are supplied with full particulars.

Annihilation of Smoke.—We recently described a smoke-annihilating apparatus, the invention of Mr. Samuel Elliott, of Newbury, by which the issuing smoke was washed into a dirty froth by the impact of dashing water. Mr. Wigham Richardson, the well-known shipbuilder, and president of the Northern Institution of Engineers, has introduced to the notice of that institution a similar discovery of a German blast-furnace maker, who constructs a chamber where water-spray deposits the issuing smoke and soot. From the resultant froth the ammonia and sulphur can be condensed and recovered, and is found, it is stated, to yield a handsome profit. It is really not too much to prophecy that future electric light companies can emulate the gas companies' example in the matter of by-products, and can have better burning fuel, absence of the smoke nuisance, and valuable products in chemicals, which shall even recoup them for the actual cost of fuel. As the present is the time that central stations are being designed which are to be erected throughout this already far too smoky land, we wish to impress upon station designers their duty at least to investigate the claims of smoke-annihilating arrangements, of which the two we have mentioned are, so far as can be judged, the most rational and economical yet promulgated.

Underground Telephone Cables in Berlin.—The underground telephone communications begun last year have just been completed. This telephone plant, the largest till now existing, has been so perfected that for many years to come an unlimited development of this important medium of communication may safely be expected. The different sections of cast-iron pipes, each containing 28 wires, branch off the numerous exchanges, and lead to several connection-boxes, where they are joined to the overhead lines. The total length of these tubes is about 34,000 yards, 10,000 yards of which are laid down as double set; 43,000 yards cast-iron pipes of ¾in. to 1¼in. diameter have been supplied for them, the biggest pipes being spacious enough for 90 cables. The total weight of the pipes is 4,500 tons, and 522 cable surface boxes in masonry are provided for testing and repairing purposes; besides there are 100 yards wrought-iron boxes and 135 trenches at the street crossings, and 215 yards of cable-boxes to cross the River Spree and the junction canals. Within one year 6,384 wires of about 3,700,000 yards length have been drawn into the pipes, 3,823 of which are now in constant working. We are told that the Imperial Post Office, after this success, intends carrying out the underground system for telephones in several other important towns.

Matriculation and Scholarships.—Of the 100 odd candidates who entered at the end of September for the matriculation examination at the City and Guilds Central

Institution, 60 passed and 16 did sufficiently well to be allowed to enter the college as unmatriculated students. In addition to the regular students in their second and third years, and the 76 above referred to, who are admitted to attend courses in all the four departments of mathematics and mechanics, engineering, physics, and chemistry, some 20 special students have entered for portions of the advanced courses in one or more of these departments. On the result of the entrance examination, the Clothworkers' Scholarship of £60 a year, with free education, tenable for two years and renewable for a third, was gained by C. E. Stamp, from St. Paul's School; and the three Institute's Scholarships, each of sufficient value to cover the student's fees for three years at the Central Institution, were gained by G. H. Baillie, from Winchester House School, C. V. Drysdale, from the Finsbury Technical College, and A. E. Sonneborn, from Tottenham College. At the end of last session the John Samuel Scholarship, granted to a meritorious student of the Central Institution at the close of his second year's course, and consisting of £30 and free education for the third year, was awarded to C. W. Clinton; the Siemens Medal, given to the student of greatest merit in the department of electrical engineering, was taken by R. Wightman.

The British Museum.—It seems to be admitted that the experiment which the Government were persuaded to make of opening the British Museum on week-day evenings, so as to enable the "workers" to save their Sunday afternoons for better uses, is a total failure, though some thousands of pounds have been spent in installing electric light in the galleries. But the fact that nobody goes lends a charm to the place, in the opinion of a weekly reviewer. As he says, the light shines alone on the placid mummy, and the still more placid policeman. Here and there a maiden aunt conducts a nephew by the hand as his last treat for the holidays, and what he fails to enjoy in the archæology he tries to make good by the reflection that he is sitting up late. (The entertainment is from eight to ten). The only other figure is the superior official in charge, who has seen it all before, and who longs to get away to the evening papers. While waiting for them, he takes the Rosetta Stone as the latest intelligence to hand. Now is the time for the harvest of the quiet eye and the quiet mind. The long galleries are as silent as any passage in a rock temple. Forty centuries blink down upon us in the ray of the arc light; and the intense brightness renders the solitude visible. You are alone with Sesostris; and, if he had such a thing about him, you might button-hole Amenophis III. This illumination ought to make the Museum a resort of fashion. Someone in society should be seen there, and take care to have it known; then all who are not in society would follow, and London would learn more of a priceless possession.—*The Metropolitan.*

Leeds.—A meeting of the Tramways Sub-committee of the Leeds Corporation was held on Tuesday, Alderman Firth, the chairman, presiding, to consider the question of running the Roundhay-road tramways by electricity. Mr. Holroyd Smith waited upon the committee and explained his system of working electric railways, and made an offer to the committee to work the Roundhay-road tramways. After consideration, the committee decided to recommend the General Committee to continue the negotiations with the Thomson-Houston Electric Company, with the view of leasing the Roundhay-road lines to that company, if the committee think satisfactory arrangements can be made, so that the matter may be brought before the Council at an early date. At the meeting of the Highways Committee on Wednesday, it was unanimously decided to adopt the recommendation of the Tramways Sub-committee. In accordance with this decision, the chairman (Alderman Firth) and the town clerk (Sir George Morrison) were desired to get a provisional agreement drawn up, so that it might be submitted to the Town Council at an early a date as possible. We understand that this particular system of electric tramcars has recommended itself to the committee from the circumstance that the company have stated that they would undertake not to charge more than 1d. per journey from Sheepscar police station to Roundhay Park, and that they would be prepared to erect plant and work the cars for two years, at the end of which experimental period they would be open to agree to terms, if desired, for the transfer of the property to the Corporation.

Mansfield Closed Conduit System. — Another closed conduit is on the scene—an apparent cross between Gordon's new system, which we have several times alluded to, and the usual third-rail bare contact. This is the invention of Mr. Frank Mansfield, of New York. It is not easy to understand the exact nature of the arrangement of the rail contacts, but the invention is thus described: A continuous well-insulated conductor is buried in the ground, and short branch conductors are run from there to the roadbed at short intervals along the tracks, but contact is open at all times, except when a car is passing over any particular spot. An electromagnet is used to lift a pivoted arm in a box in which these contacts are arranged, which not only closes the connection between the supply conductor and branch, but establishes also a sliding contact with a rail mounted on the underside of the car. The current returns through the motor and rails to the supply station. As the car passes along over the track it cuts its motor into circuit first at one contact spot and then, before breaking connection with that spot, establishing connection with another. Nothing is to be seen along the track except occasional spot boxes where the connection is to be made. We must say it is difficult to see how such an arrangement could possibly work with a continuous insulator; it is possible, however, that this word is inadvertently used for "discontinuous." Closed conduits now form an active field of experiment, and the simplest and best will win great rewards. From what we have already said, it will be seen that questions of priority will enter into this as into nearly all other practical electrical inventions.

Belgium.—The town of Ninove is the first Belgian town to renounce gas for the electric light. A 30 years' contract has been made with a Brussels firm for the public and private distribution of electricity. The installation now opened is at first sufficient to supply at any one time 1,000 16-c.p. lamps, and comprises two Siemens dynamos of 16,800 watts and two batteries of Tudor accumulators, the latter being able to supply 600 lamps for a period of 6 hours. These batteries serve both for regulation and reserve, and are arranged so as to automatically supply at 110 volts in case of any stoppage. Overhead conductors are used, of bare bronze wire 3¼ mm. diameter, run on porcelain insulators mounted on brackets along the street. The mains are supplied by five feeders, connecting the principal points of consumption. These feeders are composed of several wires run on iron chairs and insulators upon the roofs of the houses. The radius of distribution is half a mile. The public lighting is done by means of 120 lamps of 25 c.p. mounted with enamelled reflectors, placed above the now extinguished gas lamp.

The present lighting is far superior to the old, and costs no more to the authorities. A portion of the lamps are put out late at night by the use of a special switch and circuit, again being lighted at six o'clock in the winter months for the sake of the workmen proceeding to their work, Ninove being a manufacturing town of 2,000 operatives out of 7,000 inhabitants. For private lighting the current is supplied at ·9d. per 100 watt-hours (9d. per unit) at 110 volts. This price makes a slight reduction as compared with gas, which at Ninove was about 5s. a 1,000 cubic feet, after having been reduced from 6s. 6d. and 8s. in previous years. The public buildings, station, and hospital enjoy considerable reductions. The price includes the renewal of lamps. The gas concession expired on the 30th September, and the electric light commenced on 1st October, though not officially inaugurated till the 5th October. Ninove, it may be remarked, was the first town in Belgium to introduce gas.

Electric Tramways for Glasgow.—The Glasgow Town Council, at its monthly meeting last week, took a decided preliminary step towards the adoption of electric traction on their tramways. The minutes of the Tramway Committee contained a report by the sub-committee appointed to consider the question of the future working of the tramways. The committee had visited London and Birmingham, where they had seen electric tramways in operation, and they concluded by recommending that application be made in the ensuing session of Parliament for power to work the Glasgow Corporation tramways by electric and other mechanical power, the present right of working by animal power being retained. Bailie Paton, in moving the adoption of the minute, said that the sub-committee had satisfied themselves that the working of the tramways by electricity was perfectly practicable. Tramways had been working by electricity in London for 16 months, and for three months in Birmingham; and those in Birmingham were, he considered, an improvement on those in London. Indeed, the electric tramways in Birmingham were the finest in the country. They were lighted by electricity, and altogether were worth going a long way to see. All the indications were that if such a system could be adopted in Glasgow it would be a great success. They did not know the exact cost of working by electricity as compared with working by horses. They had good reason to believe that electricity would be cheaper, but before they would require to consider the subject there was no doubt the question would be decided. They did not propose to decide who should have the power of working the tramways if they got this Act. It would be wise for the Council to reserve consideration of that question in the meantime. Mr. Gray expressed satisfaction with the speedy manner in which the committee had discharged their duties in connection with this matter. Mr. Dickson stated that he had received a communication from a well-known citizen, Mr. Alex. Allan, who was travelling in America at the present time, and he said that nothing had surprised him more than the manner in which the tramway system was worked there, and the extent to which electricity was taken advantage of. The Town Council ought to be in a position to adopt electricity as early as possible. The Lord Dean of Guild endorsed what had been said by Bailie Paton. He was perfectly satisfied that the Council were doing the right thing in making this application to Parliament. Mr. M'Kellar believed that the cost of electricity would be even less than under the present system. The minute was approved, and the Corporation will therefore take steps to obtain the necessary powers.

Electrical Localities.—What a hive of electrical industry the locality at Victoria and Princes-mansions is becoming. Any provincial man passing here would see quite a galaxy of names well known in electrical fields. Messrs. Drake and Gorham were amongst the earliest discoverers of this highly professional situation. The Electrical Accessories have the same offices, Mr. Campbell Swinton is close by, and Messrs. Johnson and Phillips have recently added a further West End office at this place. Next door is the Electrical Engineering Corporation Impersonal affairs these generalities are—it is usual necessary to think of the enterprising directors, Messrs. Manville, Madgen, and Statter, and their specialities of dynamos, telpher and tram lines, to remember and discriminate. We now notice that last week Messrs. Paterson and Cooper, who have contentedly done good work in the wilds of Hoxton and Dalston, have just taken offices in this same electrical spot, Princes-mansions, Westminster. All the way down Victoria-street is rich in electrical firms, from the Edison-Swan Company near Victoria-station, in Albert-mansions, and Mather and Platt's, at one end, to Mr. Gisbert Kapp near the Westminster Bridge in Parliament-street. Victoria-mansions itself seems filled with electrical people—the Westminster Electric Supply Company, and the English Westinghouse Company; the Planet Arc Lamp can be found here, various other electrical names are continually being added in addition at intervals; away at the back Mr. Weymersch is still occupied with his battery. Across the road was the ill-fated Maxim-Weston, in a delightfully artistic set of rooms—now a chance for an intending settler; and the Bernstein Lamp has a local habitation just here. Nearing the Houses of Parliament there is the Institute itself, and its meeting place, the civil engineers' theatre, close by; Woodhouse and Rawson, ubiquitous as usual, must also have their office. Edmundson's have been an electrical show place opposite Parliament for years, and a rising firm, Messrs. A. B. Gill and Co., are at present fitting up offices at another corner. In the City, near the Mansion House Station, is another favourite electrical locality. Here electric supplies seem to flourish. The General Electric Company's offices rear their pile one side of the way, Messrs. Woodhouse and Rawson have the position opposite for their central offices, and now further have secured each end of the block in that central position, one of which has just been passed over to the Okonite Company—a late *protégé*, now fully fledged, and we are informed, having no connection with the parent company. Messrs. Poole and White in Bread-street, a minute's walk away, are making a great show in the same field, and Mr. Wilson Hartnell has his London office at the same address. Near the Mansion House itself, 11, Queen Victoria-street was once a greater centre of activities—now has the Series Traction Syndicate and the Lineff system—two companies as yet in embryo—each expected, by their supporters, to revolutionise the world of traction. Round the corner, in Walbrook, the Electric Construction Corporation continue the work of E.P.S. and Elwell-Parker. Messrs. Crompton are singular in their situation by being almost alone, and not, like the others, a nucleus for various satellites—perhaps this will come. Round Broad-street Station cluster the telegraph companies Messrs. Johnson and Phillips are up the court to the right, and the General Electric Power and Traction, of Immisch and Barking-road fame, direct operations from opposite in New Broad-street.

THE EDINBURGH EXHIBITION.—XIX.

The electrostatic voltmeters have the great advantage of being available as accurate measurers of potential on direct and alternating systems, and, being electrostatic, they use no current, and consequently require no temperature correction. They are therefore free from the causes of error so prevalent in instruments of the electromagnetic type, whose accuracy is impaired by variations of temperature, and which when used on alternating systems are affected by errors due to self-induction varying with the period of alternation. The chain of electrostatic voltmeters measures from 40 to 50,000 volts, and is composed of three distinct types—viz., the multicellular electrostatic voltmeters, the vertical electrostatic voltmeters, and the electrostatic balance. The ranges of the separate instruments, as usually made, are:

Multicellular electrostatic voltmeter	range	40 to 160
	best of range	50 to 100
,, ,, ,,	range	60 to 240
	best of range	70 to 130
,, ,, ,,	range	80 to 400
	best of range	100 to 240
,, ,, ,,	range	200 to 800
	best of range	300 to 600
,, ,, ,,	range	500 to 1,600
	best of range	700 to 1,300
Vertical ,, ,,	range	400 to 8,000
,, ,, ,,	,,	800 to 12,000
Electrostatic balance	,,	2,500 to 50,000

The instruments are made on the principle of an air condenser, having one of its parts movable about an

Fig. 1.

axis, so as to increase or diminish the capacity. The condenser is enclosed in a metal case, for the double purpose of protecting the movable part from air currents, and from the disturbing influence of any electrified body, other than the fixed portion, differing from it in potential. In all the instruments, except the electrostatic balance, the fixed portions consist of two sets of quadrant-shaped cells in metallic connection with each other, and formed by a number of parallel brass plates. These cells are fixed by an insulating support to the case of the instrument, and a terminal passes from them to an insulated binding screw on the outside of the case.

The movable portion in all the instruments is in metallic connection with the surrounding case. In the multicellular voltmeters this connection is made through the suspending wire, and in the vertical scale voltmeter and electrostatic balance through the knife edges which support the movable part. The movable portion carries the pointer which indicates by direct readings the difference of potential between the two parts of the condenser.

The action of the instrument, shortly stated, is as follows: When the fixed and movable plates are connected respectively to two points of an electric circuit, between which there exists a difference of potential, the movable plate tends to move so as to augment the electrostatic capacity of the instrument, and the magnitude of the force concerned in any case is proportional to the square of the difference of potential by which it is produced. In the use of the vertical and electrostatic balance instruments this force of attraction is balanced by the horizontal component of a weight of any convenient amount hung on the knife edge in connection with the movable part, while in the case of the multicellular it is balanced by the torsion of the suspending wire.

The arrangement of the parts of the multicellular electrostatic voltmeter is shown in Figs. 1 and 2. These figures apply to an early form of the instrument, and differ in two matters of detail from the voltmeter as now made. For simplicity in manufacture the cells are now made with straight backs, and the plates looked at in plan are, therefore, triangular. A coach spring has now been interposed between the suspending wire and the spindle carrying the vanes.

The insulated cells are formed of triangular brass plates fixed into saw cuts in a brass back piece so as to be equal distances apart and accurately parallel to each other. Two sets of these cells, C, are fixed relatively to each other, as shown in Fig. 2, by a vulcanite support to the sole-plate,

Fig. 2.

so that their plates are horizontal, and are completely enclosed within the brass cylindrical case of the instrument.

On the top of this cylinder is a shallow horizontal circular scale-box containing the scale of the instrument, and having a glass cover, which serves to protect from currents of air the movable indicator, I, and the scale and interior parts from dust.

For the movable part a number of vanes, V, similar in form to those of the quadrant electrometer are used. These vanes are placed parallel to each other on a spindle with distance pieces between them. The top end of this spindle passes through a small hole in the sole-plate of the instrument, which forms the bottom of the scale-box, and is attached to a small coach spring, which in turn is secured to one end of a fine iridio-platinum wire suspended from a torsion head at the top of a vertical brass tube. The torsion head may be turned by means of a forked key provided for the purpose, and is clamped to protect it from accidental displacement by a cap which screws on to the end of the tube. The coach spring has sufficient resilience to allow the spindle to touch a guard stop, and so saves the suspension from injury in event of the instrument being roughly set down.

Two vertical brass repelling plates, which also act as guard-plates to prevent the movable part from turning beyond its prescribed limits, are fixed to the bottom of the sole-plate. These two plates carry a guide-plate, G, with a circular opening in it, through which the lower end of the spindle passes. A little brass disc, or head, D, is attached to the end of the spindle, sufficiently large to prevent its passing back through the hole in the guide-plate. Thus the movable part is effectually secured from swinging about so as to be injured, and by no possibility can it come into contact with the insulated quadrants. When the instrument is level the spindle hangs free by the suspending wire, so that the vanes are horizontal, and each is in a plane exactly midway between those of two contiguous condenser-plates.

A small thumbscrew is placed in the centre of the base-plate below the instrument, which can be screwed in so as to lift the weight of the spindle and vanes from the suspending wire and clamp the disc on the end of the spindle against the guide-plate. A lifter or checker is also provided similar to that used in the magneto-static instruments.

An aluminium needle attached to the top of the spindle indicates, on the horizontal circular scale fixed to the upper side of the sole-plate, the difference of potential between

FIG. 3.—Vertical Electrostatic Voltmeter

the movable and fixed portions of the condenser by direct readings in volts.

To enable this multicellular to be used as an inspectional instrument capable of being read from a distance, as across an engine-room, a mirror, supported in a frame which passes over the vertical brass tube and rests upon the glass cover of the instrument, is supplied. When this mirror is in position it is at an angle of 45deg. with the plane of the sole-plate, and by reflecting the scale and pointer gives the instrument all the advantages of a vertical scale. The instrument is shown in Fig. 1 with its mirror in position.

The vertical electrostatic voltmeter is shown in Fig. 3, and as will be seen the insulated quadrants are supported with their plates vertical, and only one large vane is used. This movable plate is supported in a vertical position on knife edges, so that the plane of its motion is parallel to the two fixed plates which form the insulated quadrants. Its upper end has a fine prolongation which serves as a pointer for indicating the deflections on the scale of the instrument, and at its lower end is fixed the knife edge for the weights, having its length perpendicular to the plane in which the plate moves.

In order to save time in taking readings, an arrangement is provided for checking the oscillations of the movable plate, and stops are placed to limit its range and prevent damage to the pointer. One of these stops—the left-hand one—is made to act as a support for the vane.

The scale is graduated from 0 to 60, and the divisions represent equal differences of potential, the actual magnitude of the difference per division being dependent upon the weight in use at the time. A set of three weights is sent with each instrument, providing for three grades of measurement in the proportion of 1:2:4. Thus the instrument shows one division per 50 volts with the link (the lightest weight) alone on, one division per 100 volts with the medium weight hanging on the link, and one division per 200 volts with all three weights on.

THE TELPHER AND ELECTRIC RAILWAYS OF THE EDINBURGH EXHIBITION.*

BY E. MANVILLE, M.I.E.E., AND J. G. STATTER, A.M.I.C.E.

It may be said truly of the United Kingdom that its inhabitants are, as a whole, very slow in taking advantage of new applications of the forces of nature; and in no instance, perhaps, is this more so than in the application of electricity to traction. When at last, however, they have taken up a new application they develop it more thoroughly than other nations.

In a paper on "Electric Traction," read by Mr. Bennett before the East of Scotland Engineering Association last year, he observed that whilst there were but few lines of electric tramway in operation in the United Kingdom, not one of these existed in Scotland. The same condition of affairs pertained at the commencement of this year when, through the enterprise of the council of this exhibition, Scotchmen are enabled to see two examples of the application of electricity to traction at work in their capital.

One of these—the telpherage system—is mainly the invention of the late Prof. Fleeming Jenkin, who developed his ideas in the University of Edinburgh, and therefore this—the first telpher line erected in Scotland—should be especially interesting to you; the other—an electric tramway, worked from overhead conductors—is the first tramway completely worked by this method in the United Kingdom, and this paper is particularly descriptive of these two systems.

TELPHERAGE.

Telpherage is a distinct and special application of electricity to traction particularly suitable for the carriage of goods over rough country where the cost of railways is too great. We do not suppose that it is likely to compete with heavy railways, but it is especially applicable to replace heavy cartage where the cost of transport frequently reaches 1s. per ton mile, which is many times the cost of carrying the same quantity on a telpher line.

Light railways have up to the present time been generally erected to supersede the primitive method of carting when the quantities to be carried reach from 100 to 500 tons per diem. The cost of a light railway where bridges, embankments, and cuttings have to be made is considerable, and far in excess of the cost of a telpher line over the same country. A telpher line spans rivers, crosses roads, bridges, valleys, and generally accommodates itself to the smoothing out of excessive gradients caused by the rough surface of the country, and even when the whole line is erected over a country continually rising from end to end of the line the telpher locomotive can with facility be made to haul loads up gradients that are quite impracticable on an ordinary railway.

Ingenious devices were invented by the late Prof. F. Jenkin, and brought into practical use, to enable the train to travel automatically without any driver to control it, and a telpher train so equipped goes along the level and ascends gradients and descends gradients at approximately the same speeds, and with a delicacy of regulation that it would be hard to attain in driving a train by hand.

It is the essential idea of telpherage that, instead of carrying heavy unit loads as in a railway and running but few trains a day to do the work, the unit loads carried should be small and the trains should follow each other frequently. As the trains move across miles of country unattended by a driver, and as the speed of any one train might be greater than that of the one in front, it is necessary to have a system of blocking that shall be absolutely certain, and here electricity lends itself splendidly to the object to be achieved.

With a steam locomotive, the most that can be done to stop it is to shut off the steam from the cylinders, but in an electric locomotive it is possible, so to speak, to remove the fire from the firebox and the steam from the boiler, leaving the locomotive perfectly inert; and in arranging a block system on a telpher line the train in front is arranged to completely cut off the current from the section behind it, so that if the next train should run into this section it immediately loses all power of proceeding until the train in front has moved into a section further on; and thus all possibility of accidents by collision are completely removed.

The telpher line in the grounds of the exhibition measures about 430 yards all round. It is thus necessarily short owing to the space placed at the disposal of the Electrical Engineering Corporation, and does not meet in this short length with all the conditions that exist on lines of greater length and passing over

* Paper read at the Edinburgh International Exhibition before the Royal Scottish Society of Arts.

found, more magnetisable than cast iron, and not far inferior to wrought iron. It should form an excellent material for the cores of electromagnets for many purposes where a cheap manufacture is wanted.

A very useful alternative mode of studying the results obtained by experiment is to construct curves, such as those of Fig. 20, in which the values of the permeability are plotted out vertically in correspondence with the values of B plotted horizontally. It will be noticed that in the case of Hopkinson's specimen of annealed

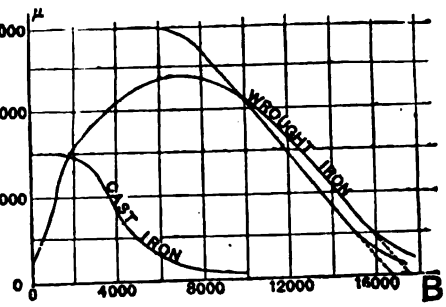


FIG. 20.—Curves of Permeability.

wrought iron, between the points where B = 7,000 and B = 16,000, the mean values of μ lie almost on a straight line, and might be approximately calculated from the equation:

$$\mu = (17{,}000 - B) \div 3 \cdot 5.$$

THE LAW OF THE ELECTROMAGNET.

Many attempts have been made, by Müller, Lamont, Frölich, and others to discover a simple algebraic formula whereby to express the relation between the magnetising force and the magnetism produced in the electromagnet. According to Müller, these are related to one another in the same proportions as the natural tangent is related to the arc which it subtends. The formulæ of Lamont and Frölich, which are more nearly in keeping with the facts, are based upon the assumption of a relation between the permeability and the degree of magnetisation present. Suppose we assume the approximation stated above, that the permeability is proportional to the difference between B and some higher limiting value (17,000 for wrought iron, 7,000 for cast iron). If this higher value is called β we may write.

$$\mu = \frac{\beta - B}{a},$$

where a is a constant that varies with the quality of the iron or steel

Now $$B = \mu H,$$

giving by substitution and an easy transformation

$$B = \beta \frac{H}{a + H},$$

which is one form of Frölich's well-known formula. The constant, a, stands for the "diacritical" value of the magnetising force, or that value which will bring up B to half the assumed limiting or "satural" value.

All such formulæ, however convenient, are insufficient, inasmuch as they fail to take into account the properties of the entire magnetic circuit.

HYSTERESIS.

I have already drawn attention to the difference between the ascending and descending curves of magnetisation, and may now

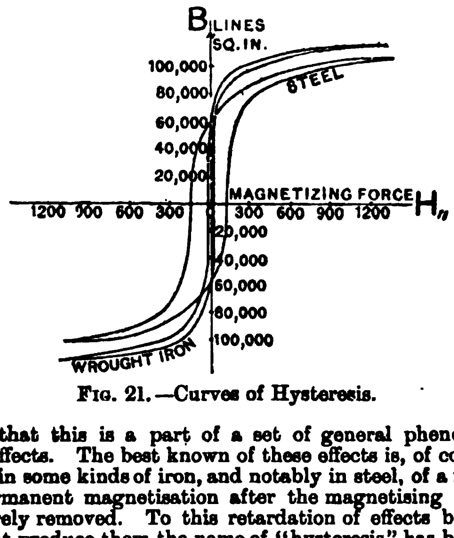


FIG. 21.—Curves of Hysteresis.

point out that this is a part of a set of general phenomena of residual effects. The best known of these effects is, of course, the existence in some kinds of iron, and notably in steel, of a remanent or sub-permanent magnetisation after the magnetising force has been entirely removed. To this retardation of effects behind the causes that produce them the name of "hysteresis" has been given by Prof. Ewing. If a piece of iron is subjected to a magnetising force which increases to a maximum, then is decreased down to zero, then reversed and carried to a negative maximum, then decreased again to zero, and so carried round an entire cycle of magnetic operations, it is observed that the curves of magnetisation form a closed area similar in general form to those shown in Fig. 21. This closed area represents the work which has been wasted or dissipated in subjecting the iron to these alternate magnetising forces. In very soft iron, where the ascending and descending curves are close together, the enclosed area is small, and as a matter of fact very little energy is dissipated in a cycle of magnetic operations. On the other hand, with hard iron, and particularly with steel, there is a great width between the curves, and there is a great waste of energy. Hysteresis may be regarded as a sort of internal or molecular magnetic friction, by reason of which alternate magnetisations cause the iron to grow hot. Hence the importance of understanding this curious effect, in view of the construction of electromagnets that are to be used with rapidly-alternating currents. The following figures of Table V. give the number of watts (1 watt = $\frac{1}{746}$ of a horse-power) wasted by hysteresis in well-laminated soft wrought iron when subjected to a succession of rapid cycles of magnetisation. It will be noted that the waste of energy increases as the magnetisation is pushed higher and higher in a disproportionate degree, the waste when B is 18,000 being six times that when B is 6,000. In the case of hard iron or steel the heat waste would be far greater.

TABLE V.—WASTE OF POWER BY HYSTERESIS.

B	$B_{\prime\prime}$	Watts wasted per cubic foot at 10 cycles per second.	Watts wasted per cubic foot at 100 cycles per second.
4,000	25,800	40	400
5,000	32,250	57·5	575
6,000	38,700	75	750
7,000	45,150	92·5	925
8,000	51,600	111	1,110
10,000	64,500	156	1,560
12,000	77,400	206	2,060
14,000	90,300	262	2,620
16,000	103,200	324	3,240
17,000	109,650	394	3,940
18,000	116,100	487	4,870

Another kind of after-effect was discovered by Ewing, and named by him "viscous hysteresis." This is the name given to the gradual creeping up of the magnetisation when a magnetic force is applied with absolute steadiness to a piece of iron. This gradual creeping up may go on for half an hour or more, and amount to several per cent. of the total magnetisation.

Another important matter is that all such actions as hammering, rolling, twisting, and the like, impair the magnetic quality of annealed soft iron. Annealed wrought iron which has never been touched by a tool shows hardly any trace of residual magnetisation, even after the application of magnetic forces. But the touch of the file will at once spoil it. Sturgeon pointed out the great importance of this point. In the specification for tenders for instruments for the British Postal Telegraphs it is laid down as a condition to be observed by the constructor that the cores must not be filed after being annealed. The continual hammering of the armature of an electromagnet against the poles may in time produce a similar effect.

FALLACIES AND FACTS ABOUT ELECTROMAGNETS.

I will conclude this lecture by stating a few of the fallacies that are current about electromagnets, and will add to them a few facts, some of which seem paradoxical. The refutation of the fallacies and the explanation of the facts will come in due course.

Fallacies.—The attraction of an electromagnet for its armature varies inversely, as the square of its distance from the poles.

The outer windings of an electromagnet are necessarily less effective than those that are close to the iron.

Hollow iron cores are as good as solid cores of the same size.

Pole-pieces add to the lifting power of an electromagnet.

It hurts an electromagnet (or, for that matter a steel magnet) to pull off the keeper suddenly. [It is the sudden slamming on that in reality hurts it.]

The resistance of the coil of an electromagnet ought to be equal to the resistance of the battery.

A coil wound left-handedly magnetises a magnet differently from a coil wound right-handedly. [It is not a question of winding of coil but of circulation of current.]

Thick-wire electromagnets are less powerful than thin-wire electromagnets.

A badly-insulated electromagnet is more powerful than one that is well insulated.

A square iron core is less powerful (as Dal Negro says, eighteen-fold!) than a round core of equal weight.

The attraction of an electromagnet for its keeper is necessarily less strong (one-third according to Du Moncel) sideways than when the keeper is in front of the poles.

Putting a tube of iron outside the coils of an electromagnet makes it attract a distant armature more powerfully.

Facts.—A bar electromagnet with a convex pole holds on tighter to a flat-ended armature than one with a flat pole does.

A thin round disc of iron laid upon the flat round end of an electromagnet (the pole end being slightly larger than the disc) the disc is not attracted, and will not stick on, even if laid down quite centrally.

If a flat armature of iron be presented to the poles of a horseshoe electromagnet the attraction at a short distance is greater if the armature is presented flankways than if it is presented edgeways. On the contrary, the tractive force in contact is greater edgeways than flankways.

Electromagnets with long limbs are practically no better than those with short limbs for sticking on to masses of iron.

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WOODHOUSE AND RAWSON.

It is excusable for the directors of a company to try and make the best possible use of the shareholders' money, in order to pay the said shareholders as large dividends as possible. It is understood that the operations of the directors are in accordance with the memorandum and articles of association. Usually these are drafted wide enough to cover a multitude of operations, and large dividends are generally supposed to cover a multitude of sins. The report and balance-sheet of Messrs. Woodhouse and Rawson has been published in our columns, and a lengthy report of the ordinary meeting will be found elsewhere in this issue, but it needs a very clever man to gain any real knowledge from report, balance-sheet, or meeting. The shareholders are, or ought as men's minds go, to be satisfied with a good dividend. They are reaping the benefit of their confidence in the directors; whether they are reaping any benefit from their business as a trading and manufacturing concern is another matter. The term manufacturing is used in its ordinary sense, and does not apply to the manufacturing of companies. One of the shareholders was inquisitive; he would have liked to know how much of the profits was due to trading, and how much to company promotion. The general public, or at any rate, that part of the general public interested in electrical matters, is as inquisitive as this shareholder, and would like to know a good deal about the profits, but the chairman—wise in his generation, like all good chairmen—decided that to give such information would not be politic. Suavely answering the question, he says in effect: "It is not usual to give this information, so rest content with your dividend and kick not against the pricks." The directors have done well for the shareholders—they may in the future do as well or even better—yet the question has frequently been asked, Is this a sound method of conducting business? The answer is yes, or is no, according as it is viewed from one standpoint or from the other. If we are to consider the company as making dividends for the shareholders by company promotion, there is no legitimate objection to its so doing. If we are to consider the company as a representative of the electrical industry, making dividends as a supplier or manufacturer, a false glamour is put upon electrical work. The investing public must not be led to suppose that such large profits can be obtained by trading operations of the magnitude under discussion. Other companies and other firms cannot approach these profits with the same bulk of trade. How is that? asks the outsider. Of course, those who watch the state of affairs understand that, while Messrs. Woodhouse and Rawson may make ordinary profits upon trading, their extraordinary profits are not so made. We are inquisitive, like the shareholder, and should

very much like to know the ratio the one profit bears to the other. There are two points in this mixed business concern to which attention should be called. First, that if a number of second-rate companies are promoted, although it may pay for the moment, the time will inevitably come when anything from such sources will meet with no favour. Success in obtaining quotation on the Stock Exchange and running up the price of shares is but a fleeting show, and lacks what the shareholders want, viz., permanence. Secondly, the subsidiary companies can be made by judicious management to assure the permanent success of the parent company—the latter manufacturing and supplying the initial needs of the former till they can run alone, in fact, always supplying that apparatus which the parent company makes and the others do not. Take a lesson from co-operators, where the wholesale branch supplies the retail branches. An examination of the companies promoted, however, hardly bears out the view of a far-seeing policy—rather of a policy of hand-to-mouth, and let the future take care of itself.

THE RUSH OF BUSINESS.

A boom in electrical work has set in during the last three months which is fairly carrying many electrical men almost off their legs. Nothing like it has been experienced since the time of the crop of electrical companies in the early part of the decade, which, unfortunately, as we all know, led but to inflation, bursting of the bubble, and much disappointment both to real electrical engineers as well as to investors. Since then the progress has been gradual, but ever increasing in strength. The parliamentary Act has at last got into working order; powers have been applied for right and left, central stations not a few have been begun and are working. Now that another winter season is in sight, the rush for electrical work is becoming in some quarters almost embarrassing. We continue to hear of works being enlarged, and of new enterprises undertaken. Something large may be expected to occur over the City lighting, which is now almost upon us, and the introduction to the metropolis of arc lighting cannot but make its influence felt in every provincial town, as well as those even more numerous towns dependent upon us in the British protectorates abroad and in the colonies. It is sincerely to be hoped that the extension of activity which has set in will be confined, as it should be, to actual installations, organisation of works, and manufacturing facilities, rather than to the too great inflation of company stock beyond their dividend - bearing dimensions. The continued increase of business will be viewed by all, except gas interests, as a welcome fact for the coming season.

ELECTRIC TRACTION AND LOCAL AUTHORITIES.

The present position of local authorities towards electric lighting and traction companies is not and never has been very encouraging. The authorities, in many cases, endeavour to put obstacles in the way of either the development of electric lighting or traction, and frequently have succeeded in delaying for a certain time the introduction of either the one or the other. We will, however, only refer to one instance which will be worth placing on record. We refer to the position taken up by the Hammersmith Vestry towards the Lineff Electric Traction Syndicate, Limited, and the West Metropolitan Tramway Company. It will be remembered that the latter company obtained about the end of 1887 or in the beginning of 1888 an Act granting permission to use electricity on their tram lines. This Act was not obtained without considerable expense on the part of those interested in promoting the Bill. Moreover, the Hammersmith Vestry actually squandered the ratepayers' money to the tune of over £1,000 in opposing the Bill, but their efforts were unsuccessful, and the Bill became an Act. The West Metropolitan Tramway Company then set to work in order to carry out their powers, it being their intention to employ the Lineff open - conduit system. The opposition of the local authorities to the slot, and particularly that of the Hammersmith Vestry, was so great, that the idea of laying down the system was abandoned.

The Act remained, for the time being, a dead letter, as although it authorised the use of electric traction, yet, we believe, no specific powers were given allowing the company to break open the roadway to lay down the conductor.

Time passed away, and the Lineff closed-conduit system was elaborated. This, of course, entirely surmounted the objections raised against the slot method. It was proposed to apply this system either on the Hammersmith-Kew line, or on that from Young's Corner to Uxbridge-road. Three local authorities were concerned: the Brentford Local Board, the Chiswick Local Board, and the Hammersmith Vestry. The permission of each of these was asked to lay down the magnetic conductor. The two former readily gave their consent, but the latter, with its over-cautiousness, again opposed the application and refused to grant it. It seemed, therefore, that no system of electric traction could possibly please the Hammersmith Vestry, and that a special Act would have to be obtained authorising the breaking up of the roadway. Pressure was, however, brought to bear upon that authority, and with apparently good results. The Vestry has, we are pleased to learn, decided to grant the application of the tramway company, "subject to a favourable report being received from an expert whom they will appoint." The expert to report to the Vestry is, we believe, Prof. Kennedy.

The battle now appears to be over, and we may expect to see, in the course of a few months, a practical working line on the Lineff closed-conduit system in the West of London. That nearly three years should have been wasted owing to the opposition of mainly one local authority, conveys a moral which ought not to be disregarded. Life is not worth living if we have to wait for absolute perfection, and when a scheme is known to be commercially workable, there ought to be the possibility of testing it on a practical scale long before the expiration of three years.

THE NEW CABLES BETWEEN PERU AND CHILI.

The cable steamer "Silvertown," owned by the India Rubber, Gutta Percha, and Telegraph Works Company (generally known as the Silvertown Company), left Greenhithe on October 11 for the west coast of South America.

On the preceding day (Oct. 10) a large company of guests met at lunch on board the ship at Greenhithe, to bid farewell to their friends and to wish the expedition "God-speed."

Thanks to the kindness of some of the gentlemen connected with the company, we were able to obtain a few

extremities, are in contact with the lead of the roof. The highest spire was found after the storm to be bulged and blackened at the junction of the iron with the lead. There are numerous metal rhones or drain-pipes down the walls for carrying off the rain water. These are in contact with the leadwork of the roof above, but no provision is made for earthing them below; in fact, they are built into brick drains. When I add that there is no lightning conductor, and that the house is built on a thin layer of soil covering rock, it will be seen that—the existence of the telephone wires being taken into account—all the elements necessary for a first-class catastrophe were present. The absence of a conductor was accounted for by saying that when the house was built the architect stated that one was unnecessary. The proprietor was especially desirous of knowing how the electric light and telephone wires, which were wholly under cover and cased in, came to be struck. The explanation is not difficult. As is well understood, lightning is a discharge between two areas (these areas corresponding to the coatings of a Leyden jar) highly charged by electricity of the opposite signs. The clouds usually form one of these areas, and a high or prominent object on the earth the other. The principal path of a discharge is always that of the least resistance, or best conductivity, although partial discharges may likewise occur simultaneously by less perfect routes, and the discharge takes place as soon as the accumulated tension is high enough to overcome the resistance between the areas. A high point on the earth's surface is generally selected by the lightning, because whatsoever its nature it is usually, owing to the presence of moisture on its surface or in its pores, a better conductor than the air surrounding it. If it is a perfect conductor or supports a perfect conductor of sufficient capacity in connection with the earth and with all adjacent metallic masses, the discharge passes from its extremity to its base without developing any noticeable phenomena; at any rate nothing which is likely to cause danger to life or property, although it has been asserted that in the case of a very violent flash side discharges from the conductor of dangerous moment occur in spite of the best earth connection. This, however, has been inferred rather from laboratory experiments than actually proved. If the precautions which I shall endeavour to prescribe and impress upon you as necessary are faithfully followed, such side discharges, should they happen, would probably be of inconsequence. A flash may very likely leap from the conductor to neighbouring masses of metal if these are connected to earth, and not to the conductor, especially if the earth of the conductor itself is a poor one; but so leaving them without a metallic link to the conductor would be a trifling with experience. On the other hand, if one or more sections of bad conductivity intervene between the summit and the earth, the discharge, although it will pass, will no longer do so harmlessly, but will develop explosive violence at the badly conducting gaps. Its general course will still be the path of least resistance, but it may fly to and traverse any metal that lies in anything like a direct line between the summit and the earth even if that metal only offers a path of a few feet. This tendency to leave the conductor will be increased proportionally as the earth connection is imperfect, a fact that will account in the case under consideration for the lightning striking the electric light wires; they, although covered and unconnected with the earth, offered the path of least resistance for a portion of the distance, and formed a connecting link between the point at which the lightning entered the dwelling and the point at which it left.

The enquiry seemed to indicate a discharge from the valley to the clouds, *viâ* the telephone wires, electric light leads, chimneys and spires, the intervening air spaces within the house being jumped. The lightning, on this assumption, entered the wires at the stables by leaping from the old telegraph earth to the telephone terminals, and by piercing the insulation at and on each side of the stream. Arriving at the house, it jumped from the telephone terminals to the box containing the electric light fuses and thence travelled by the leads into every room in the house. There it jumped to grates, pipes, and other metallic masses, and so to the metal of the roof and away. A noteworthy point, and one which is replete with instruction to electricians, is that had the house not possessed telephonic connection with the valley it might, owing to its position on a badly-conducting rock, have escaped altogether; and had it not had electric light and bell leads in every room it still might have escaped in spite of the telephone wires. On the other hand, had not such a golden bridge as was offered by the leads existed, a leap from the basement to the roof through the body of the house might have been attended by utterly disastrous consequences. But the accident does not teach that we should deny ourselves the advantages attendant on telephones and electric lights. It teaches rather that these conveniences may be a source of danger if inconsiderately and carelessly fitted, just as gas or stoves, or lamps may become centres of danger if ignorantly or recklessly dealt with. When telephone wires, and especially metallic circuits, are taken into a building, they should be fitted as near the point of entry as possible, with a good lightning discharge. This necessity I recognised several years ago as a consequence of more than one accident, since when all metallic circuits constructed by the National Telephone Company have been so fitted. Such a discharge, costing only a few pence, would in all probability have shunted the lightning to earth, and the inmates of the house might not have even been aware that a discharge had taken place. Telephones working with an earth return do not require such care as metallic circuits.

A discharge of lightning through a conductor may be roughly illustrated by hydraulic analogy. Let us suppose a long perpendicular pipe with a number of lateral holes at intervals, its bottom extremity opening into a large empty cavity. A mass of water caused to fall suddenly into its upper end would descend through the pipe into the cavity, and having no resistance but the friction of the pipe and the resistance of the air in the pipe to overcome, it would so fall without any, or but little, of the water escaping through the lateral holes. This answers to a lightning-conductor of sufficient capacity having a good earth. A pipe of small diameter opening into a large cavity would represent a conductor of insufficient capacity, though with a good earth. Through this thin pipe the water could only flow comparatively slowly, and the tendency to leakage through the lateral holes would be considerably increased.

Now, imagine a large pipe with an obstacle placed at its bottom so that the diameter is reduced one-half, or a large pipe opening into a cavity incapable of containing the water let down; then the water descending with a tremendous impact is partially stopped by the obstacle, or by the filling up of the cavity. The water will rebound and spurt violently out of the lateral holes. This corresponds to a conductor of sufficient capacity connected to an insufficient earth, and the effects will be exaggerated proportionally as the aperture at the bottom is reduced. If the same pipe is taken with the bottom end plugged up the stoppage and spurting of the water will be greatly augmented, and perhaps the pipe will burst from the suddenly exerted lateral pressure. This answers to a conductor with a very imperfect earth. The analogy is striking here; the water, like the electricity, is seeking earth—its lowest level—but failing to find it through the pipe spurts or bursts out laterally, and then recommences its descent by the nearest channel it can find. The water may have to turn corners and run down flights of stairs on the way, so the electricity may have to avail itself of anything conducting, whether it lies directly in the path or not.

I now propose to detail the recommendations I have made with the view of preventing a recurrence of the accident at this particular house. The example is a peculiar one in more than one respect, but still the recommendations embody the precautions which, with variations due to local surroundings, are necessary in every case. The main object is obviously to provide a path of small resistance between the roof and the nearest earth. Owing to the rocky foundations of the house this would seem to be at the stream in the valley and its vicinity, as the unusual mercy of a pioneer flash has clearly enough indicated.

The leaden roof, with its spires which rise above everything, may be left as it is, but seeing that rarefied air and soot are both conductors—comparatively poor ones, it is true, but still almost infinitely superior to air at the normal pressure—and that there are something like 40 chimneys opening above the roof, it is obvious that, taken collectively, the chimneys, especially when fires are on, present a conducting surface of very large area, and consequently of low resistance between the interior of the house and the atmosphere above it. When fires are burning this conducting surface may extend, in the shape of a column of rarefied air, considerably above the highest spire. To prevent the electricity selecting this conducting path of chimneys in parallel a better one must be provided, and this can fortunately be accomplished, as pointed out by Dr. Lodge, by erecting a skeleton cage of wire provided with a few pointed upright pieces above each group of vents, so that it may be enveloped by the rarefied air ascending therefrom. Each cage should have a soldered connection to the leaden roof, or by means of an iron wire direct to one of the conductors. These conductors may consist of at least four—preferably more—galvanised iron wires (No. 4 B.W.G.) carried from soldered connections with the metal of the roof to the ground at as many different parts of the house—say, at each corner and at convenient intermediate points, and thence continued without break of continuity—and buried without boxing in a trench dug close to the boxing containing the telephone wires as far as the stream in the valley. The stables should be similarly treated, all the metal ridges of the roof, gutters, etc., being joined together by wire, at least one point projecting above everything else, and thence by means of two No. 4 wires laid in a trench also as far as the stream. There the water should be temporarily dammed back or diverted, and a hole excavated in the bed of the stream some 3ft. deep by 3ft. square. Into the hole a few bushels of retort carbon from a gas works should be rammed; some 12ft. of each of the six iron wires—four from the house and two from the stables—should be coiled upon the carbon; then some more carbon well rammed down. Finally, the hole should be filled by well-rammed soil (not rock) and the water allowed to flow

over it. If inconvenient to dam or divert the stream, the hole may be dug at one side of the water, and the water admitted over it when completed. There will then exist from the highest point of the house to the highest point of the stables a conductor making good earth at one place at least and as good as the nature of the soil will permit at all others along the route, which is approximately that of the telephone wires. In the presence of such an arrangement there would be no inducement for electricity to jump through several feet of air, and pierce thick guttapercha insulation to invade the telephone wires. Further, in the house, all systems of pipes or other masses of metal, such as grates, boilers, etc., should have connections with at least one of the conductors. Such connections may be of No. 5 B.W.G. galvanised iron wire, and should be soldered wherever possible. Of course, neither the electric light, nor the electric bell, nor the telephone wires can be so connected without interfering with their proper functions. This is a little unfortunate, but they may be dealt with by encasing a couple of feet of each of them in metal pipes with indiarubber or porcelain rings between the leads and pipe, so as to make actual metallic contact impossible, while at the same time providing the shortest possible path for lightning between the three sets of leads. This would be attained by connecting the three lengths of pipe together and to the conductors by means of a No. 5 galvanised iron wire soldered. In addition, the telephone wires should be fitted with an ordinary discharge at their place of entry. The object of these branch connections is, of course, to prevent any jumping in the house whatever may happen in future. If the main earth connection became insufficient from any cause the lightning would again make for the stream *vià* the telephone wires, but if all metallic masses in the house, and the light and telephone wires, are treated as described, it would do so without any dangerous discharge. The only jump would be across the air space between the tubes and leads inside them and through the insulation, and this would be entirely harmless.

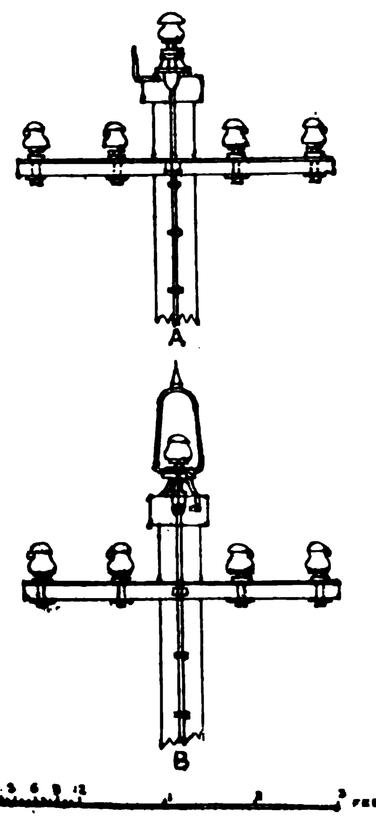
I recommend iron wire because—for the theoretical reasons adduced by Prof. Hughes and Dr. Oliver Lodge, into which I have no time to-day to enter, and with which many of you are no doubt perfectly familiar—iron is now widely admitted to be as effective as copper for currents appertaining to the character of lightning, and because iron has been employed habitually in America, in France, and elsewhere for a long period, and there is no evidence forthcoming to show that the percentage of accidents in those countries has been greater than in Great Britain, which has hitherto adhered rigorously to copper. True, some authorities still advocate the use of copper, but the greater cost of that metal precludes its employment so liberally about a building as could be wished, and when the greatest use has to be made of a certain sum I consider, theoretical reasons apart, that it is beyond comparison wiser to invest that sum in six or eight iron conductors than in one or two copper ones. Copper would be preferable on account of its greater durability when buried, but still galvanised iron will endure for years when so treated. Theoretically, a conductor of flat section like hoop iron would be better than wire, but is more liable to decay. In addition to such conductors as described being fitted, the existing drain-pipes should be connected to the roof by soldered wires or bands, and connected at their lower extremities to the conductors by a No. 5 galvanised iron wire carried round and soldered to each of them, and a flagstaff standing about 20 yards from the house should have an iron wire run up it and connected to the conductors. In fixing the cables sudden bends or changes of direction should be avoided. If all these precautions are taken, and the connections are examined from time to time and repaired when necessary, the chances of another visitation from lightning will be very remote.

As before remarked, the recommendations are designed for a special case, and would not be applicable in all their details to many others. Still, to secure immunity from lightning, certain invariable precautions have to be taken in all cases. These are specially, firstly, having at least one metal point—multiple points are much better—in as perfect connection with the earth as possible, preferably by several paths, raised above all stone, wood, and other non-conducting portions of the building. These points should be preferably over or quite close to the chimneys unless wire cages are provided specially for them; secondly, connecting all pipes, grates, bell-wires, and other masses of metal in the house to the conductors, preferably by means of soldered connections. When this cannot be managed, as with light and telephone leads, then by providing a small air space across which the discharge may jump harmlessly. Thirdly, by securing a good earth. When a house is built on rock, or on a thin stratum of soil over rock, or on chalk, this point requires special attention and study. Where gas and water pipes exist, they should be joined to the conductors both above and below the ground, and gas and water meters should be bridged by soldered No. 5 wire. Even when water-pipes exist Dr. Lodge considers it better to provide a separate earth for the conductor—also attaching it to the pipes—but this is a refinement I have not myself adopted when good water mains, always full, and jointed with lead, have been at hand.

These are the three important points to keep in view in designing protective systems for buildings, and the architect or engineer should see personally that his design is carried out. If such precautions were general, we should hear less of mysterious fires than we do. One thing has been brought out over and over again in connection with lightning conductors. Ordinary workmen are quite untrustworthy, and require constant supervision.

In conclusion, I am able to show you some effects of a recent lightning storm, which emphasise the necessity of having the highest point of any structure earthed. Last month a telephone wire erected on the tops of poles between Murtle and Cults in Aberdeenshire was struck. The wire was out of use, and was insulated at both ends, so that the lightning found no vent at the extremities. It accordingly struck through the solid porcelain insulalors to the iron bolts supporting them, and jumped thence to the earth-wire, which was stapled up the poles to within an inch or two of the bolts. It shattered the insulators on the 1st, 2nd, 7th, 15th, and 35th poles, counting from Murtle. At three of the poles the wire, No. 18 B.W.G. silicium bronze, was fused, and at the foot of one pole the earth was disturbed and the grass burnt. Three of the insulators with fragments are on the table before you; the others were reduced entirely to small pieces, many of which could not be found. On one of those before you a metallic deposit from the fused wire is distinctly visible. Had each pole carried an earthed point raised above the topmost wire, the discharge would, almost to a certainty, have neglected the path of far higher resistance through the wire and porcelain, and all damage would have been avoided.

This is a weak point in our telegraphic practice, common to post office, railway and telephone companies, and one which I have raised my voice against for a good many years past. In



the figure, A shows the ordinary method of terminating the earth-wire, which leaves the topmost line unprotected, and B the method I have adopted with the object of shielding it.

In house practice the analogy to the short earth-wire is a system of gas or water pipes, bell or other wires, extending up to, say, the attics, with a non-conducting structure of plaster, wood, and slates intervening between the highest point touched by the metal and the air of the house. This non-conducting stratum absolutely does not exist when lightning is in question, and, in the event of a discharge occurring between the metal in the house and the clouds above, would be shattered and scattered just as you see these insulators have been. It is a curious question what the precise nature of the force is that splits porcelain in the manner shown. The destruction of trees and telegraph poles by lightning has been attributed to the sudden generation of steam in the pores of the wood due to the heat of the discharge or to expansion by the heat of the air which the wood contains; but in porcelain there is neither moisture nor air; yet, as you see, when it chances to intervene in the path of the least resistance, that does not prevent it from being split up and utterly destroyed.

BOARD OF TRADE RULES.

REGULATIONS AND CONDITIONS FOR SECURING THE SAFETY OF THE PUBLIC AND FOR ENSURING A PROPER AND SUFFICIENT SUPPLY OF ELECTRICAL ENERGY, MADE BY THE BOARD OF TRADE UNDER THE PROVISIONS OF THE ELECTRIC LIGHTING ACTS, 1882 AND 1888, AND OF THE METROPOLITAN ELECTRIC SUPPLY COMPANY (WEST LONDON) LIGHTING ORDER, 1889.

Definitions.

In the following regulations—

The expression "the order" means the Metropolitan Electric Supply Company (West London) Lighting Order, 1889.

The expression "the undertakers" means the undertakers for the purpose of the order.

The expression "consumer" means any body or person supplied or entitled to be supplied with energy by the undertakers.

The expression "consumer's terminals" means the ends of the electric lines situate upon any consumer's premises and belonging to him at which the supply of energy is delivered from the service lines.

The expression "consumer's wires" means any electric lines on a consumer's premises which are connected with the service lines of the undertakers at the consumer's terminals.

The expression "aerial conductor" means any conductor which is placed above ground and in the open air.

The expression "pressure" means the difference of electrical potential between any two conductors through which a supply of energy is given, or between any part of either conductor and the earth; pressure on any alternating-current system being taken to be the equivalent of pressure on a continuous-current system when it produces an equal heating effect if applied to the ends of a thin stretched wire or carbon filament; and (*a.*) Where the conditions of the supply are such that the pressure cannot at any time exceed 300 volts, if continuous, or the equivalent of 150 volts, if alternating, the supply shall be deemed a low-pressure supply; (*b.*) Where the conditions of the supply are such that the pressure may exceed the limits of a low-pressure supply, but cannot exceed 3,000 volts, or the equivalent of 3,000 volts, whether continuous or alternating, the supply shall be deemed a high-pressure supply; (*c.*) Where the conditions of the supply are such that the pressure may on either system exceed 3,000 volts, or the equivalent of 3,000 volts, the supply shall be deemed an extra high-pressure supply.

Mains, service lines, and other conductors and apparatus are referred to as low-pressure, high-pressure, and extra high-pressure mains, etc., according to the conditions of the supply delivered through the same or particular portion thereof.

Provided that in the case of conductors laid under the surface of the ground in conduits, in accordance with these regulations, and being the property or under the sole charge of the undertakers, low-pressure conductor shall mean any conductor in which the pressure between that conductor and the earth cannot at any time if continuous exceed 300 volts, or if alternating, 150 volts, or between that conductor and any other conductor laid in the same conduit cannot at any time if continuous exceed 500 volts, or if alternating, 250 volts.

When any casing, support for conductors, conducting wire, or other metallic body is required to be efficiently connected to earth, it shall be deemed to be so connected when it is connected to metallic mains for water supply outside of buildings, or where these are not available, to a mass of metal having a total surface of at least four square feet, buried to a depth of at least 3ft. in moist earth, by means of a conductor possessing mechanical strength, and offering a passage to electrical discharges equal to that of a strand of seven No. 16 galvanised iron wires.

The expression "daily penalty" means a penalty for each day on which any offence is continued after conviction thereof.

All other expressions to which meanings are assigned in the order or principal Act have the same respective meanings in these regulations.

I.—REGULATIONS AS TO SAFETY.

General.

1. Save as hereinafter provided, the supply of energy delivered to the consumer's terminals shall be a low-pressure supply.

2. A high-pressure supply shall not be delivered to any consumer's terminals, except for special purposes, and with the approval of the Board of Trade on the joint application of the consumer and the undertakers, and subject to such further regulations as the Board of Trade may from time to time prescribe. But a high-pressure supply may be given to distributing or converting stations or points, or to distributing mains, in accordance with the following regulations.

3. An extra high-pressure supply shall not be given except to distributing stations or other premises in the sole occupation of the undertakers, and with the written consent of the Board of Trade, and subject to such regulations and conditions as the Board may prescribe.

Mains and other Conductors.

4. The maximum working current shall not be sufficient to raise the temperature of the conductors or any parts thereof to such an extent as to materially alter the physical condition or specific resistance of the insulating covering, if any, or in any case to raise such temperature to a greater extent than 30deg. of Fahrenheit's thermometer; and efficient automatic means shall be provided which will render it impossible for this maximum working current by any accident to exceed such limit to the extent of 50 per centum, even for short intervals of time, and special care shall be taken that the cross-sectional area and conductivity at joints are sufficient to avoid local heating, and that the joints are protected against corrosion.

5. Where any portions of any conductors are exposed in such a position as to be liable to be affected by lightning, they shall be efficiently protected against accident by appliances of such pattern and construction as may from time to time be approved by the Board of Trade.

6. Where any high-pressure conductors, other than aerial conductors, are placed above the surface of the ground, they shall be completely enclosed in brickwork, masonry, or cement concrete, or in strong metal casing efficiently connected to earth.

7. Where any high-pressure conductors are laid in subways, or in the same conduits with any low-pressure conductors, they shall be completely enclosed in strong metal casing efficiently connected to earth.

8. Where any high-pressure conductor is laid within a less distance than 18in. from any low-pressure conductor or from the surface of the ground, or where any low-pressure conductor is laid within the above-mentioned distance from any previously laid high-pressure conductor, efficient means shall be taken to render it impossible that the low-pressure conductor or the surface of the ground shall become electrically charged by any leakage from or defect in the high-pressure conductor.

9. Every high-pressure conductor shall be continuously insulated with a durable and efficient material, which shall be protected on the outside against injury or removal by abrasion, and every such conductor shall be tested for insulation after having been laid in position and before any joints for service lines are made. The insulation resistance under these conditions shall not be less in any section of the conductor than at the rate 100,000 ohms per mile for every volt of pressure of the supply under a testing pressure of at least 100 volts, and the undertakers shall duly record the results of the tests of each conductor, or section of a conductor, and at all times permit an electric inspector to examine and take copies of such record.

10. The insulation resistance of any complete circuit used for high-pressure supply, including all devices for producing, consuming, or measuring energy, connected to such circuit, shall be such that should any part of the circuit be put to earth through a resistance of 2,000 ohms, the leakage current shall not exceed 0·04 ampere in the case of continuous currents, or 0·02 ampere in the case of alternating currents. Every such circuit shall be fitted with an instrument of such pattern and construction as may from time to time be approved by the Board of Trade, which shall immediately indicate any defect which may at any time occur in the insulation resistance of either conductor. Every such circuit shall be tested for insulation at least once in every week, and the undertakers shall duly record the results of such testings, and at all times permit an electric inspector to examine and take copies of such record.

11. In the case of a high-pressure supply on any alternating-current system, where separately insulated conductors are laid in the same conduit, or pass through the same boxes, precautions shall be taken against the discharge of electric sparks between the insulating covering of oppositely charged conductors, by providing a sufficient connection of a conducting nature from one covering to the other throughout.

Conduits.

12. All conduits used as receptacles for conductors shall be constructed of durable material, and of ample strength to resist any pressure due to heavy traffic or other forces to which they may be expected to be subjected.

13. Where the conductors in any conduit are not continuously insulated, adequate precautions shall be taken to ensure that no accumulation of water shall take place in any part sufficient to raise the level of the water into contact with the conductors.

14. All conduits for conductors constructed in streets in which gas mains are also laid, shall be efficiently protected against an accumulation of gas.

15. All street boxes shall be efficiently protected against an accumulation of gas or water, and their covers so secured that they cannot be opened except by mean of a special appliance.

Converting Stations.

16. Converting stations, or points in a system of distribution to which a high-pressure supply is given from generating stations, and from which a low-pressure supply is given to one or more consumers, and which are not on the consumer's premises, shall be established in suitable places, which are in the sole occupation and charge of the undertakers.

17. In every case where the supply is transformed at a converting station as described in the preceding regulation, some means or apparatus approved by the Board of Trade shall be provided which shall render it impossible that the low-pressure distributing mains shall be at any time charged to a dangerous difference of potential from the earth, owing to any accidental contact with, or leakage from, the high-pressure system either within or without the converting station.

Consumer's Premises.

18. Where the general supply of energy is a high-pressure supply, and transforming apparatus is installed on the consumer's premises, connected to the distributing mains by high-pressure service lines, and to the consumer's terminals by low-pressure service lines, the whole of the high-pressure service lines, conductors, and apparatus, including the transforming apparatus itself,

so far as they shall be on the consumer's premises, shall be completely enclosed in solid walls, or in strong metal casing efficiently connected to earth, and securely fastened throughout.

19. In every case where any transforming apparatus is installed on the consumer's premises, as described in the preceding regulation, some means or apparatus approved by the Board of Trade shall be provided, which shall render it impossible that the low-pressure service lines and consumer's wires shall be at any time charged to a dangerous difference of potential from the earth, owing to any accidental contact with, or leakage from, the high-pressure system either within or without the transformer.

20. All terminals, low-pressure service lines, or other apparatus, between the transforming apparatus or other source of supply and the consumer's terminals, so far as they shall be on the consumer's premises, shall be completely enclosed in insulating cases or coated with insulating material in such a manner that no part of them can be touched by any person without the removal of such case or coating, and wherever exposed shall be efficiently protected against injury to the insulation.

21. The undertakers shall be responsible for all electric lines, fittings, and apparatus belonging to them, or under their control, which may be upon the consumer's premises being maintained in a safe condition and in all respects fit for supplying energy.

22. In delivering the energy to the consumer's terminals the undertakers shall exercise all due precautions, so as to avoid risk of causing fire on the premises.

23. If the undertakers are reasonably satisfied, after making all proper examination by testing or otherwise, that a connection with the earth exists at some part of a circuit of such resistance as to be a source of danger, and that such connection does not exist at any part of the circuit belonging to the undertakers, then and in such case any officer of the undertakers, and duly authorised by them in writing, may, for the purpose of discovering whether such connection with the earth exists at any part of a circuit within or upon any consumer's premises, at all reasonable times, after giving one hour's notice of his intention to do so, enter any such premises and disconnect the consumer's wires from the service lines, and may require the consumer to permit him to inspect and test the wires and fittings belonging to the consumer and forming part of the circuit.

24. If on such testing the officer discovers that a connection exists between the consumer's wires and the earth, and that such connection has an electrical resistance not exceeding 5,000 ohms, or if the consumer does not give all due facilities for such inspection and testing, the undertakers shall forthwith discontinue the supply of energy to the premises in question, giving immediate notice of such discontinuance to the consumer, and shall not recommence such supply until they are reasonably satisfied that such connection with the earth has been removed. Provided that in cases where the maximum power taken by any consumer exceeds 25,000 watts, the consumer's wires may be divided for the purposes of this testing into separate circuits, the insulation resistance of each of which shall exceed 5,000 ohms.

25. If any consumer is dissatisfied with the action of the undertakers either in discontinuing or in not recommencing the supply of energy to his premises, the wires and fittings of such consumer may, on his application and on payment of the prescribed fee, be tested for the existence of connection with the earth by an electric inspector, or if no electric inspector has been appointed, by a person appointed by the Board of Trade. This regulation shall be endorsed on every notice given under the provisions of the last preceding regulation.

Regulations as to Aerial Conductors where erected with necessary consents.

26. An aerial conductor shall not in any part thereof be at a less height from the ground than 20ft., or where it crosses a street, 35ft., or within 7ft. of any building or erection other than a support for the conductor, except where brought into a building for the purpose of supply.

27. Service lines from aerial conductors shall be led as directly as possible to insulators firmly attached to some portion of the consumer's premises which is not accessible to any person without the use of a ladder or other special appliance, and from this point of attachment to the consumer's terminals they shall be enclosed and protected in accordance with the preceding regulations as to service lines on the consumer's premises.

28. Every aerial conductor shall be attached to supports at intervals not exceeding 200ft. where the direction of the conductor is straight, or 150ft. where this direction is curved, or where the conductor makes a horizontal angle at the point of support.

29. Every support of aerial conductors shall be of a durable material, and properly stayed against forces due to wind pressure, change of direction of the conductors, or unequal lengths of span, and the conductors and suspending wires (if any) shall be securely attached to insulators fixed to the supports. The factor of safety for the conductors and suspending wires shall be at least six and for all other parts of the structure at least 12, taking the maximum possible wind pressure at 50lb. per square foot. No addition need be made for a possible accumulation of snow.

30. Every support, if of metal, shall be efficiently connected to earth, and if of wood or other non-conducting material, shall be protected by a lightning conductor fastened to its support along its entire length, and projecting above the support to a height of at least 6in., such lightning conductor being efficiently connected to earth.

31. Where any aerial conductor crosses a street, the angle between such conductor and the direction of the street at the place of such crossing shall not be less than 60deg., and the spans shall be as short as possible.

32. Where any aerial conductor belonging to the undertakers is erected so as to cross any other aerial conductor or any suspended wire used for purposes other than the supply of energy, precautions shall be taken by the undertakers against the possibility of their conductor coming into contact with such other conductor or wire coming into contact with their conductor by breakage or otherwise.

33. Every high-pressure aerial conductor shall be continuously insulated with a durable and efficient material to be approved by the Board of Trade to a thickness of not less than one-tenth part of an inch, and in cases where the extreme difference of potential in the circuit exceeds 2,000 volts the thickness of insulation shall not be less in inches or parts of an inch than the number obtained by dividing the number expressing the volts by 20,000. This insulation shall be further efficiently protected on the outside against injury or removal by abrasion. If this protection be wholly or partly metallic it shall be efficiently connected to earth.

34. The material used for insulating any high-pressure aerial conductor shall be such as will not be liable to injurious change of physical structure or condition when exposed to any temperature between the limits of 0deg. and 150deg., or to contact with the ordinary atmosphere of towns or manufacturing districts.

35. Every aerial high-pressure conductor shall be efficiently suspended by means of non-metallic ligaments to suspended wires, so that the weight of the conductor does not produce in it any sensible stress in the direction of its length, and the insulated conductors and suspending wires, where attached to supports, shall be in contact only with material of highly insulating quality, and shall be so attached and guarded, that in case they break away it shall not be possible for them to fall away clear of the support.

36. The undertakers shall be responsible for the efficiency of every support to which their aerial conductors are attached, and every such support shall be marked to indicate the ownership of the conductor.

37. Every aerial conductor belonging to the undertakers, including its supports and all the structural parts and electrical appliances and devices belonging to or connected with it, shall be duly and efficiently supervised and maintained as regards both electrical and mechanical conditions.

38. The undertakers shall not permit any aerial conductor to remain erected after it has ceased to be used for the supply of energy, unless they intend within a reasonable time again to take it into use.

Penalties.

39. If the undertakers make default in complying with any of the preceding regulations they shall be liable to a penalty not exceeding £10 for every such default, and to a daily penalty not exceeding £10. The imposition of any penalty under this regulation shall not affect the liability of the undertakers to make compensation in respect of any damage or injury which may be caused by reason of such default.

II.—Regulations as to Supply.

1. One week at least before the undertakers are ready to commence to supply energy through any feeding, charging, or distributing mains, they shall serve a notice upon the county council and the local authority of their intention to commence such supply.

2. From and after the time when the undertakers commence to supply energy through any distributing mains, they shall maintain a supply of sufficient power for the use of all the consumers for the time being entitled to be supplied for such main; and such supply shall, except so far as may be otherwise agreed upon from time to time between the county council and the undertakers, be constantly maintained at such pressure as may be fixed under the provisions of these regulations. Provided that, for the purposes of testing, the authority by whom the electric inspector is appointed may give permission to the undertakers to discontinue the supply at such intervals of time and for such periods as it may think expedient, and that for any other purposes connected with the efficient working of the undertaking, the undertakers may, with the permission of the Board of Trade, discontinue the supply at such intervals of time and for such periods as the Board of Trade may think expedient. Where the supply is so discontinued notice of such discontinuance, and of the probable duration thereof, shall be forthwith served upon the county council and the local authority.

3. The system of distributing mains shall be so arranged in sections that in case it becomes necessary to stop the supply through any portion of a main for more than one hour for the purposes of repairs, or for any other reason, the stoppage of supply will in no case exceed in amount a maximum power of 200,000 watts, or extend to the premises of more than 80 consumers, and in the case of every stoppage for more than one hour reasonable notice shall be previously given by the undertakers to every consumer affected thereby, except in cases of emergency.

4. During the whole of the period when a supply of energy is required to be maintained by the undertakers in the distributing mains under the order and these regulations, it shall be maintained at a constant pressure (in these regulations termed "the standard pressure") to be fixed as hereinafter specified, but such standard pressure may be different for different portions of the distributing mains. Provided that the undertakers shall be deemed to have complied with the requirements of this regulation so long as the pressure does not at any point vary more than 3 per cent. from the corresponding standard pressure in the case of a general supply at low pressure, or 2 per cent. in the case of a general supply at high pressure, unless changes in pressure recur so frequently as to cause unsteadiness in the supply.

5. The standard pressure shall be fixed by the undertakers for every pair of distributing mains, and notice of the amount of such standard pressure shall be given to the county council before the undertakers commence to supply energy to consumers through such mains, and such standard pressure shall not be altered except by permission of the county council, and upon such terms and conditions as the county council may impose, and after public notice has been given during a period of one month, in such manner as the county council may require, of the intention of the undertakers to apply for permission to alter the same. The undertakers may appeal against any decision of the county council under this regulation to the Board of Trade, whose decision shall be final.

6. Before commencing to give a supply of energy to any consumer, the undertakers shall declare to such consumer the constant pressure at which they propose to supply energy at his terminals. The pressure so declared at any pair of consumer's terminals shall not, except by agreement, be greater than 115 volts or less than 45 volts, if continuous, or the equivalents thereof respectively, if alternating, and shall not at any time be altered or departed from except in consequence of any authorised alteration of the corresponding standard pressure. In distribution on the three-wire system, the central terminal shall for the purposes of this regulation be considered to form a pair with either of the outer terminals, and similarly for multiple-wire systems; and, in the case of a transformation of energy on the consumer's premises, the undertakers shall give the consumer the choice of a supply at either of two different pressures, one of which shall be approximately half the other, and in such case the pressure so chosen by the consumer shall be declared constant pressure.

7. The variation of pressure at any consumer's terminals shall not under any conditions of the supply which the consume r is entitled to receive, nor at any time, exceed 4 per centum from the declared constant pressure, whether such variation be due to the resistance of the service lines or apparatus belonging to the undertakers, or to any action or effect produced by such apparatus, for which the consumer cannot be shown to be responsible, or, partly to any variation of pressure in the distributing mains from which the supply is taken.

8. If the undertakers make default in complying with any of these regulations as to supply, they shall, subject to the provisions of the order, be liable to a penalty not exceeding £5 for every such default, and to a daily penalty not exceeding £5.

These regulations are made subject to the power of the Board of Trade to make such further or other regulations as they may think expedient; and nothing in these regulations shall be construed to authorise the undertakers to lay any electric line or work their undertaking otherwise than in accordance with the order and the principal Act, or to supply energy otherwise than by a system for the time being approved of by the Board of Trade under the order.

COMPANIES' MEETINGS.

WOODHOUSE AND RAWSON.

The general meeting of Woodhouse and Rawson United, Limited, was held on Friday at Winchester House, Old Broad-street, E.C., under the presidency of the Right Hon. Lord Aberdare, P.C., G.C.B. (the chairman of the Company).

The **Secretary** (Mr. George Worrall) read the notice convening the meeting; the report and accounts were taken as read.

The **Chairman**: Before moving the adoption of the report, there are two points in it to which, for fear of misapprehension, I desire to call your attention. One is that the ordinary shares, of which one-half remains uncalled, are the shares taken by the public. The shares allotted to the vendors are, of course, fully paid, as shown in the balance-sheet. The other point is this: We mention in our report that the Sociedad Espenola de Electricidad has placed its lighting in the hands of this Company. The actual contract was made between that company and Woodhouse and Rawson, Limited. This contract was taken over by us, and at the present time the Barcelona Company is engaged in carrying out our suggestions. There are two ways in which a board of directors may report to their shareholders their proceedings for the past year. They may either present a report containing net results in the briefest and most succinct form, leaving to the chairman the task of supplying in his speech the facts and events which he thinks likely to interest the shareholders, or they may add to the bare statement of results a detailed account of their operations, and of the development of their undertaking, thus enabling those interested to form an estimate of their actual position, and to forecast the prospects of the future. This latter method, which has the advantage of placing on permanent record the actual position of the Company, and of giving to absent shareholders information which would otherwise be denied them, seems specially advisable at the first meeting of a Company conducting operations of so varied and extensive a description as ours, for it is clear that much may be stated in a printed report which would be tedious and out of place in a chairman's speech. We have therefore chosen the latter alternative, which has this further advantage, that it relieves the Chairman from the necessity of making a long speech. Those who have carefully studied the report will see how numerous and important our operations are. To some they may, perhaps, seem incongruous, although a little reflection will show that in reality they are closely connected. The manufacturing supply and contract departments explain themselves. The development of the business of taking up and bringing out new inventions, by the purchase of patents, by manufacturing under royalties to inventors—all these items of electrical work are closely connected with yet another large and lucrative portion of business, that of aiding in the formation of companies to work patents which require capital beyond their means, and to supply the experience which they do not possess. All these branches of electrical business were undertaken by the several companies which were purchased and absorbed into ours at the time of its formation. They have in their various departments been extended as rapidly as the short period of our existence has permitted. The manufacturing, supply, and contract departments show no inconsiderable improvements in actual performance, and give what I may venture to call well-grounded promise of greater expansion and profits hereafter. With these the report has dealt, I think, at sufficient length, presenting altogether a picture of great activity at home and abroad. In my opinion, these three branches of manufacture, supply, and contract constitute the solid basis on which the ultimate success of the Company should rest. But it is obvious that expectations of large profits from these sources can only be gradually realised; time is needed: we must sow before we can reap. It is unusual and inadvisable to enter minutely into the source of profits of the year in the case of a manufacturing company like ours, but this much I may say: the large profits of the present year which have enabled us to recommend a dividend of 15 per cent. per annum, without availing ourselves of the £75,000 deposited with us by the Woodhouse and Rawson, Limited, as a guarantee for a dividend of that amount for three years; which have enabled us to place £25,030 to reserve funds, and to carry forward over £16,000 to next year's account, after writing off £7,421, against the estimated value of our patents—these large profits have been mainly derived from the fourth branch of our business, as described in the report—viz., "the testing and proving of new patents and inventions connected with electrical and engineering science, and the introduction to the public, either by arrangements for working such inventions by this Company, or by assisting the owners in forming separate companies for working them." Such was the operation of the Woodhouse and Rawson, Limited, in introducing the Elmore process, which the present company are, with every prospect of success, extending over the chief commercial countries of Europe. Such was the formation of the International Okonite Company, described in the report. Such, although incidentally connected with our business, was the disposal of a portion of our premises at West Kensington to the West Kensington Co-operative Stores, Limited, an operation advantageous to ourselves and, I trust, to the company which acquired our property, and was launched under our auspices. That there is a certain risk involved in the introduction of new inventions it would be absurd to deny. But this I can honestly say, that these operations have never been undertaken without the most careful enquiry, and that all the judgment, experience, and knowledge of affairs possessed by the Board have been exercised before embarking in them. They represent, in fact, but a small, and a very small, portion of the proposals for the Board's assistance, in one form or another, the vast majority of which were rejected, not always from distrust of their merits, but because we limited ourselves to the selection of such only as seemed thoroughly sound and of intrinsic value. I have said that the Board had brought its combined faculties to the consideration of all schemes adopted by them; but it is the merest act of justice to our managing director, Mr. F. L. Rawson, to say that the success which has hitherto attended us is mainly due to his initiative, and to the extraordinary energy and ability of which he has given proof. Nor can I refrain from expressing my personal sense of gratitude to our vice-chairman, Sir Rawson Rawson, for his great exertions, and for his unremitting attention to the affairs of the Company during the long period when a severe illness, with its debilitating consequences, had prevented me from giving to those affairs the attention which may fairly be expected from the Chairman. Never was personal aid, at the cost of great labour, more cheerfully given, nor more effectually. To my other colleagues I venture to tender my grateful acknowledgment of their indulgence to my shortcomings. The report refers in by no means exaggerated terms to the unusual demands on the time of the staff due to the pressure on a new company engaged in such extensive operations. I beg to add my own acknowledgments, and to recommend warmly to your acceptance the adoption of the resolution for the formation of an employés pension fund. May I, as my parting contribution to the conduct of your affairs, venture to make some suggestions, the fruit for the past year's experience in the working of the Company? First, I think it very desirable that our capital should be increased, and I trust that the Directors will ere long submit resolutions to you with this object. The report has told you that we have already extended considerably the business and the business premises of the companies we were formed to acquire and consolidate. I am satisfied that these extensions cannot be fully developed, nor made as profitable as they might be, without an addition to our working capital. At present we have, as you know, the use, as capital, of the £75,000 deposited with us by Woodhouse and Rawson, Limited; but this money must be replaced, at latest, two years hence. It might well be worth while to repay it at an earlier date, if we can came to a satisfactory arrangement with the liquidators on fair conditions as to discount or other allowance. It would, doubtless, be a great advantage to the liquidators to have it repaid, so that they might finally complete their liquidation. This is matter for the future, but I think it advisable to prepare you for possible proposals in this direction. My other suggestions relate to an increase in the numbers of your Board and of the working staff. I have already referred to the labour and responsibility which have rested on your Board during the past year in the conduct of your general

paid off, and as the interest and sinking fund contributions have now ceased, there will in future be a saving of revenue on this account of about £5,000 per annum. The Company's £320,000 6 per cent. debentures mature for payment at par on February 1, 1891, and the Directors have decided to pay them off on that date by issuing a similar amount of 4 per cent. mortgage debenture stock.

NEW COMPANIES REGISTERED.

Bullers, Limited.—Registered by Waterlow Bros. and Layton, Limited, 24 and 25, Birchin-lane, E.C., with a capital of £200,000 in £10 shares. Object: to acquire, upon such terms as may be thought fit, all or any of the assets, and to undertake all or any of the liabilities, of the business of engineers, contractors, and otherwise heretofore carried on by a company named Buller, Johnson and Co., now in voluntary liquidation, and to carry on, develop, and extend the said business when acquired; to manufacture, sell, let on hire, and generally to acquire, dispose of, and deal in electrical plant, and in electricity and electric power and other forms of power and energy. The first subscribers are:

	Shares.
E. Buller, 49, Charlotte-road, Birmingham	1
H. Jobson, Summer-hill, Kidderminster	1
E. J. Chambers, Lingwood, St. James-road, Dudley	1
W. Greenhill, Dudley	1
E. P. Jobson, Dudley	1
A. T. Buller, Greystoke, Penrith	1
J. T. Harris, The Kayes, Stone, Staffordshire	1

There shall not be less than two nor more than seven Directors. The first are Ernest Wentworth Buller and Howard C. Jobson. Qualification: 100 shares.

PROVISIONAL PATENTS, 1890.

OCTOBER 6.

15777. **Improvements in electric meters.** Benjamin Joseph Barnard Mills, 23, Southampton-buildings, London. (Tony Blein, France.)

15791. **Improvements in methods and apparatus for the transmission of power.** Benjamin Joseph Barnard Mills, 23, Southampton-buildings, London. (Thomas Alva Edison, United States.) (Complete specification.)

15792. **Improvements in incandescent electric lamps, and leading-in wires therefor.** Benjamin Joseph Barnard Mills, 23, Southampton-buildings, London. (Thomas Alva Edison, United States.)

15798. **Improvements in or relating to microphones.** Alfred Julius Boult, 323, High Holborn, London. (Elophe Poirson, France.)

OCTOBER 7.

15819. **Improvements in electric dynamos, electric motors, transformers of electric currents, and induction coils.** James Johnstone, 8, Merchiston-park, Edinburgh.

15828. **Improvements in dynamo machines.** William Falconer King, 154, St. Vincent-street, Glasgow.

15869. **Improvements in multiple switchboards.** Christen Rees Bonné, 41, Eastcheap, London. (Mix and Genest, Limited, Germany.)

15871. **Improvements in multiple switchboards.** Christen Rees Bonné, 41, Eastcheap, London. (Mix and Genest, Limited, Germany.)

15873. **Improvements in multiple switchboards.** Christen Rees Bonne, 41, Eastcheap, London. (Mix and Genest, Limited, Germany.)

15874. **New and improved means or apparatus for preventing noise in telephonic apparatus.** Jules Cerpaux, 33, Chancery-lane, London.

15890. **Improvements in automatic electrical firing apparatus for naval and military ordnance.** Rudolf Dick, 37, Chancery-lane, London.

OCTOBER 8.

15921. **Improvements in and relating to incandescent electric lamps.** Robert Dick and James Duncan Maclean, 96, Buchanan-street, Glasgow.

15933. **Actuating photographic camera shutters by electro-magnetic and electro-voltaic means.** Simon Edward Kelf and Ewald Heuner, 189, Southampton-street, Reading.

15974. **Improvements in coin-freed apparatus for administering electricity.** Hubert Samuel Heath, Excelsior Cottage, Lea Bridge Gardens, Leyton.

OCTOBER 9.

16005. **Improvements in separators for galvanic batteries.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

16054. **Improvements in electric batteries.** Henri Georges Charles Serrin, 45, Southampton-buildings, London.

16034. **Improvements in the process of manufacturing composition insulators for electrical purposes, applicable also to other articles made of fire-resisting composition.** Joseph Trecziok, 7, Angel-road, Hammersmith, London.

16055. **Improvements in electric batteries.** Henri Georges Charles Serrin, 45, Southampton-buildings, London.

16057. **Improvements in pillars and electroliers or pendants for electric lamps.** Richard Brown Evered and Thomas Rudling, 45, Southampton-buildings, London.

OCTOBER 10.

16064. **Improvements in electrical secondary batteries.** James Kent Pumpelly and Frank Butterworth, 62, St. Vincent-street, Glasgow. (Complete specification.)

16104. **Improvements in self-contained electric bells and indicators.** William Thomas Pressland, 4, Moorfields, London.

16110. **Improvements in the distribution of electricity.** Thomas Parker, John Harold Woodward, and Edmund Scott Gustave Rees, 47, Lincoln's-inn-fields, London.

16124. **Improvements in electric clocks.** David Fairgrieve, 20, High Holborn, London. (Complete specification)

OCTOBER 11.

16136. **Improvements in coin-freed apparatus for obtaining a current of electricity for producing electric light, or for other purposes.** Herbert John Dowsing and Henry Sherley Price, 115, Cannon-street, London.

16153. **Improved means of manufacturing glass conduits or tubes for electrical or other purposes.** Dan Rylands, Stairfoot, Barnsley.

16156. **Improving mains for carrying currents of electric matter.** James Johnstone, 8, Merchiston-park, Edinburgh.

16221. **Improvements in electric meters.** Anthony Reckenzaun, 20, High Holborn, London.

16222. **Improvements in lanterns or lamps for arc electric lights, and in posts or columns therefor.** Alfred Lyster Shepard, 45, Southampton-buildings, London.

16223. **Improvements in the parts of electric meters connecting the movement of the solenoid with the calculating train.** Henry Burrow, 30, Bridge-street, St. Andrew's, Norwich.

SPECIFICATIONS PUBLISHED.

1881.

5338. **Secondary batteries.** Fitzgerald and others. (Third edition.) 8d.

1884.

3256. **Switches for electrical conductors.** Holmes. (Second edition.) 8d.

1889.

14860. **Telephone devices.** Hoffmann. 11d.
15609. **Electrical railway switch, etc.** Bachmann. 8d.
16165. **Electric coupling for cut-outs.** Lancaster (Grivolas). 6d.
17831. **Electric battery carbon, etc.** Sherrin. 6d.
18159. **Electric contact apparatus.** Weuste. 8d.
18360. **Dynamos.** Renshaw. 6d.
19195. **Laying electric, etc., wires in streets.** Summers. 6d.
19835. **Electrical signalling apparatus for railways.** M. and T. Perls. 1s. 1d.

1890.

5474. **Regulating electric circuits.** Lyon and Leslie. 8d.
6878. **Electric alarm for clocks.** Schmitz. 8d.
8599. **Generating, etc., electric currents.** Anderson. 8d.
8800. **Electric accumulators.** Thompson (Peral). 8d.
10421. **Preventing accidents from overheating of electrical wires.** Bradford. 6d.
11402. **Couplings for electric railway vehicles.** Pfingst. 8d.
11465. **Riveting by electricity.** Dewey. 8d.
12566. **Electric arc lamps.** Russell. 8d.
13006. **Welding metals by electricity.** Lake (Thomson). 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	$1\frac{3}{4}$
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	$5\frac{1}{2}$
London Electric Supply	5	$2\frac{1}{2}$
Swan United	3 [illegible]	$5\frac{1}{2}$
Crompton & Co., Pref.	[illegible]	$5\frac{1}{2}$
National Telephone	[illegible]	$5\frac{1}{2}$
Electric Construction	[illegible]	8

NOTES.

Southport.—The Town Council have resolved to apply for an order.

Magdeburg.—It has been decided to grant £75,000 for the erection of a central station.

Paris Lighting.—The Cance Co. have a central station in Paris, the h.p. available being 300 (French).

Belgium.—The Government are said to have adopted the Dejongh telephonic apparatus on their circuits.

Harrogate.—A sub-committee of the Town Council are considering the Corporation's proposed application for an order.

Ipswich.—The Town Council have received copies of the Ipswich Electric Supply Co.'s order, and the matter has been referred to a committee.

Chiswick.—The question of an order for the Local Board to supply electricity in Chiswick has been referred to the Works Committee for consideration.

Moss Side (Lancs.).—The Local Board and the Manchester House-to-House Company have been in correspondence as to lighting the town, and appear likely to come to terms.

Charlestown (Mass.). — It is probable that the barracks here will be lighted electrically before long, the officials of the Navy Department having petitioned on the subject.

Whitby.—The Local Board have resolved to apply for a provisional order. The Yorkshire House-to-House and the East Coast Electric Light Companies have served notices on the Board.

Boiler Explosion.—A boiler explosion is reported to have occurred on Monday evening at the Edison electric works in the Palais Royal, by which two workmen were seriously scalded.

Book Received.—We have received a copy of "Sound, Light, and Heat," an elementary class book by J. Spencer, B.Sc., F.C.S. It is published by Percival and Co., of King-street, Covent Garden.

Blackpool (Lancs.).—A scheme is on foot to construct a new pier at South Shore, and plans and estimates have already been got out. If it is carried out there should be some electric lights wanted.

Eton.—The Eton Local Authority, who have hitherto refused to give their consent to the application of the Windsor and Eton Electric Lighting Co. for an order, at their last meeting gave the required permission.

Henley's Telegraph Works.—We have received a copy of Henley's price list of electric light cables and wires which give full and clear particulars to intending purchasers. Prices are also given of jointing material and wood casings.

Boston (U.S.).—The Massachusetts Legislature have passed a Bill authorising the West End Street Railway Company to build elevated electric railways. It is probable that the third rail system of supplying current will be adopted. The proposed line is about five miles long.

Sale.—A sale by Messrs. Wheatley Kirk, Price, and Goulty of electrical plant, formerly the property of the City of Westminster Electrical Syndicate, will be held at the new supply station, Eccleston-place, S.W., at 11 for 12 o'clock on the 31st inst. Particulars will be found elsewhere.

Fareham Lighting. — Apparently there is a little friction at Fareham, for we hear of an extraordinary meeting of the Local Board being convened to consider the action of a resident in cutting the wires. The clerk was instructed to take steps to obtain an injunction against the individual in question.

A Correction.—We are informed by Mr. H. B. Bourne that our reference to himself in a paragraph which appeared in our last issue is somewhat inaccurate. He points out that his connection with the Okonite Co. is confined to the London office, and that the engineer to the company is Mr. Thos. Connolly.

Tenders Wanted for Spain.—In another column will be found an intimation from the Municipality of Caceres, Estremadura, that they are desirous of introducing the electric light in the town. Full particulars can be obtained of Don Dionisio Viniegra Villarreal, Calle Gallegos, Caceres.

National Safe Deposit Company.—At the ordinary meeting of this company, held on Wednesday, a shareholder opined that the directors ought to adopt the electric light. We think so too. But perhaps they will when the lighting of the City is a fact, and they have the necessary current at their doors.

Lightning Arrester.—According to the *Street Railway Journal*, the lightning arrester of the Short Electric Railway Co. proved itself remarkably efficient during last month, when the United States was visited by very frequent and severe thunderstorms. It states that the company did not lose a single armature.

A Large Wimshurst Machine.—M. Ducretet, of Paris, has constructed a large Wimshurst machine which he has given to the Société d'Encouragement pour l'Industrie Nationale. The glass discs, of which there are 12, are 75 centimetres (29·53in.) in diameter. The machine will give a spark 42 centimetres (16·54in.) long.

The Cost of Orders. — Accrington Corporation is reported to have spent £440 in obtaining powers under the Electric Lighting Act; and the Haslingden Local Authority were recently told by their official adviser that they might look forward to having to disburse between £250 and £300 to attain the same object.

Electric Welding.—The Thomson Electric Welding Company has leased three complete machines to Mr. Edison for use at the Schenectady works in welding copper wire from No. 20 to one-half inch, says the *Electrical World*. It is reported that they will be delivered within 30 days, and are expected to make 3,000 welds per day.

Monmouth.—Tenders are required for lighting Monmouth, and they must be sent in on or before the 1st Nov. This seems rather short notice, and we should not wonder if we have to chronicle in this, as so frequently happens in other cases of the sort, an extension of the time to some later date. We notice that the Corporation have pinned their faith to the "low-tension system."

Electric Railway in Yorkshire.—It is stated that a scheme is being promoted for the construction of an electric railway from Flamborough to the North-Eastern Railway Station, a distance of two and a half miles. A resident in the neighbourhood has interested himself in the

matter, and has been canvassing fish merchants and others with the object of obtaining their support.

Leamington.—The differences between the Town Council and the electric lighting company seem to occupy a considerable portion of each meeting of the public body. The councillors (having, so it is stated, tested the lamps) say the candle-power is deficient, the company are reported to express their satisfaction with it. We shall be surprised if the lawyers do not gain by the controversy.

Electric Fog Signalling.—The trial of the electric fog signals brought out by Mr. W. Andrews, of Nottingham, with the co-operation of Mr. Arthur Guy, some description of which will be found on p.306 of our issue for the 10th inst., were tried last week on the Great Northern Railway Co.'s line near Bowes Park in the presence of the officials. The result of the trials was, we understand, very satisfactory.

The Telephone on the Congo.—The *Bulletin International* says that the "Ville de Ramaho," one of the Walford Co.'s steamers which lately sailed from Antwerp, took out the material for erecting the first telephone line on the Congo, which is to be run alongside the Congo Railway. Phosphor bronze wire is to be used, with Dejongh apparatus with magneto bell as made by MM. Mourlon and Co., of Brussels.

Spain.—The use of electricity for lighting purposes is said to be spreading in Spain, and especially in Madrid. Though the Madrid Gas Company has for a long term of years the privilege of lighting streets and public thoroughfares, two foreign and some native companies are competing for supplying the capital with electricity. An Anglo-Spanish company this week began to supply theatres, shops, and private houses.

Lewes.—Another public meeting was held last week, at which the Mayor presided, and stated that he and Alderman Farncombe had been to Bath and Taunton, and were favourably impressed with the lighting there. The result of the talking was that the Corporation were forthwith to make enquiries with a view of substituting electricity for gas as a means of lighting the town; and a poll of the town was to be taken.

St. Saviour's.—At the last meeting of the St. Saviour's Board of Works the question of consenting to the application of the Brush Company for a provisional order again came up. Major Webber urged the claims of the company, stating that it was the practice of the Board of Trade to give power to two companies in each district, and at present there was only one in St. Saviour's—viz., the London Electric Supply. Nothing was settled.

Concentric Wiring.—We have received from Mr. J. D. F. Andrews, of 41, Parliament-street, S.W., a copy of his rules for concentric wiring. As the author very pertinently remarks, and this applies to any and every system of wiring, "if it is not introduced upon a systematic basis, and is carelessly and flimsily carried out, the advantages it presents will be entirely overthrown." The rules appear to have been carefully compiled and are clear and methodical.

Bradford (Yorks.).—The report of the Gas and Electric Supply Committee to the Town Council states that since the opening of the works, on September 20th, 1889, there has been a regular supply maintained on all circuits, and the committee has found it necessary to put down additional appliances, which will greatly increase the output without materially adding to the cost of the works. At the same time they have had to spend over £13,000 on their gas works for extensions and improvements. Just so! it's a case of more light everywhere.

Standards of E.M.F.—MM. Chassagny and Abraham have been making certain researches into the heat conductivity of metals. The experiments were carried out with iron-copper couples, each formed of a wire of iron ½ mm. diameter and a copper wire ·3 mm. diameter. The percentage of pure iron was 99·7, and of pure copper 98·7. The results showed that thermo-electric elements were very comparable the one with the other, and that they might prove useful as E.M.F. standards, their agreement appearing to the experimenters to be better than that of electro-chemical elements.

Darmstadt.—The central station has been enlarged by the addition of a 200-h.p. engine driving two dynamos of 66,000 watts each. Besides, there are now three steam engines of 100 h.p. each, and one engine of 80 h.p. in the station. The former drives two of Siemens and Halske's dynamos at 210 revolutions, the latter drives similar dynamos at 220 revolutions. A storage battery is also installed. The distributing network is on the three-wire system, and consists of about 30,000 yards of lead-covered and iron-armoured cable (Siemens and Halske's manufacture) feeding about 50,000 lamps.

Brazilian Submarine Telegraph Company.—At the thirty-fourth ordinary general meeting of this company a dividend at the rate of 6 per cent. per annum was declared, together with a bonus of 3s. per share, or altogether 7½ per cent. In the course of his speech, reported in another column, the chairman alluded to the rock ahead in the shape of the termination of their concession some two or three years hence. Much was being done with reference to this event, he said, and the board was keeping a vigilant watch in order to be able to do their best to maintain the shareholders' interests when the proper time came.

Spanish-African Cables.—The following communication has been received from the Foreign Office: "A despatch has been received from her Majesty's Ambassador at Madrid, enclosing copies of a Royal decree authorising fresh tenders to be invited for the construction of the telegraph cables between the Peninsula and the Spanish possessions on the North Coast of Africa." The new conditions are slightly different from those referred to in our issue of Aug. 29, p.169. None of the tenders received in answer to the first application have been accepted. The conditions (in Spanish) may be seen at the commercial department of the Foreign Office, London, between the hours of 11 and 5.

Germany.—Several small towns have given orders for the erection of central stations. The lighting of Blankenburg-on-Harz will be carried out by Naglo Bros. for 127,000 marks (£6,350). The plant for Landsberg (Bavaria) has been ordered from the Allgemeine Elektricitats Gesellschaft, Munich. Moreover, electric traction is making progress in this country, the town of Gera in Thuringen having decided for the erection of an electric railway for passenger traffic only, whilst in Dortmund the Berlin-Allgemeine Electricitats Gesellschaft has acquired from the German Local and Street Railway Company the tramway lines in order to run electric cars, the conductors being overhead.

Northampton.—At a recent meeting of the Town Council the committee entrusted with the matter reported that tenders for wiring the new town hall buildings had been received from Crompton and Co., Limited, the Brush

Electrical Engineering Co., T. Brown and Co., Laing, Wharton, and Down, and Rooper and Tozer, and recommended that the Northampton Electric Light Co. be requested to provide and lay the wiring for the new town hall buildings, at prices not to exceed the average of the tenders of these five firms. The end of some discussion was that the report was referred back to the committee "with instructions." We understand that Messrs. Crompton and Co. are to supply and erect the machinery.

City Fruit Market.—The first stone of the new City fruit and vegetable market was laid by the Lord Mayor on Wednesday. It is situated at the junction of Charterhouse-street and Farringdon-road, and will occupy an area of 30,000ft. super. Mr. Alexander Peebles, the City architect, is the designer, and the estimated cost is £80,000. At a subsequent luncheon in honour of the event, the Lord Mayor said that he did not despair of the gas and electric light supply being under the control of the Corporation—some day. As the new market comes within the area of the western City lighting district, tenders for which are now being asked, we may hope to see the building lighted, as all such buildings should be lighted, by the electric light.

Lighting in America.—We have received No. 2 of *Whipple's Reports* for October. It contains a long and useful list of central station and street railway companies in America. With regard to the present state of electrical business Whipple says: "Reports from various sections of the country indicate a healthy state of trade throughout the many ramifications of the electrical business. In some sections of the West there was a temporary depression during the summer, but our reports this month indicate that activity is once more the rule. The cause of the depression in some of the South-Western States was due in part to the late completion of building contracts, and in part to the increased number of electrical firms who were asking for business."

Who and Where is He?—A Continental paper, devoted to finance, has delivered itself of the following precious nonsense: Dr. Mandeuft, of Geneva, has found out a way of producing electricity for nothing. With a half-horse machine he can feed 500 lamps. The apparatus is made up of a hollow sphere of zinc of 50 cm. diameter, and a massive sphere of copper 40 cm. diameter. The copper revolves inside the zinc sphere, and the two revolve at the same time, but in opposite directions, at the rate of 500 revolutions a minute. Steam at a pressure of six atmospheres is delivered into the gap between the spheres, and a current is produced, the pressure of which may be increased by increasing the revolutions and the steam pressure. Trials made in London with M. Mandeuft's first machine are quite bewildering the scientific world.

Sunderland.—Last week the Corporation Highways Committee considered the report of the Electric Lighting Sub-committee, which recommended that an order be applied for. The borough engineer estimated that 8,750 16-c.p. lights would probably be sufficient for the streets proposed to be lighted, and recommended that 10,000 be provided for. On Wednesday last, acting on this advice, the Corporation Highways Committee decided to apply for an order. There appears to be a large number of tradesmen in the town who are ready and anxious to adopt the electric light. We are sorry, however, to see that the borough engineer is in favour of 16-c.p. lamps for street lighting. We do not think they are adapted for it, and they certainly do not appear to be appreciated at Leamington. The Sunderland Corporation seem to be of opinion that the cost of obtaining their order will not exceed £50.

An Unpleasant Idea.—We have heard of the following idea before, but we cannot say that our liking for it grows with its age. A Paris doctor wants to introduce the art of electroplating our dead selves with copper. This is how we are told he proceeds. First he embalms the body which is to be kept, after which it is placed in a bath of concentrated solution of nitrate of silver, from which, having undergone sundry other operations, it comes out the colour of polished silver. A very thin layer of copper is then deposited on the features, which are afterwards varnished, a thorough resemblance to the original being the aim kept steadily in view. To copper an infant the cost would be about 300 or 400 francs, and for a grown person from 3,000 to 4,000 francs. Once coppered, moreover—and this may appeal powerfully to some of us—nothing is easier than to have the body silvered or gilded according to taste. Talk about gilding the pill!

Godalming.—We noticed the other day that Godalming was going to try the electric light again, and this time with the advantage of all the benefits to be derived by some eight or nine years experience—often very dearly bought. The first lights seen in Godalming were introduced in December, 1881, by Messrs. Calder and Barrett, and consisted of seven Siemens arc lamps and some Swan incandescents. The motive power for driving the dynamos, also of Siemens' make, was derived from two turbines, whilst a semi-portable steam engine by Wallis and Steevens, of Basingstoke, was kept as a stand-by. The machines were placed in Pullman's Leather Works, which were also lighted. The lights do not seem to have been a great success, and the local policeman is reported to have discovered that the shortest remedy for an extinguished arc was to violently shake the lamppost, a proceeding which frequently produced the desired effect. We manage things better now. We believe the lighting was discontinued before the winter of 1882 set in.

Pollak's Miners' Lamp.—This lamp is thus described in a recent note to the Academie des Sciences (Paris): A rectangular ebonite box holds Pollak accumulators, which rest on a metal plate. An ebonite cover supports an incandescent lamp, enclosed in a thick glass globe. The whole is covered by a metal cap, bolted into place. A sheet of soft rubber, between the ebonite cover and the box, hermetically closes it. Rods of rustless metal are let into the cover having platinum contacts at their base, which rest on the platinum contacts of the accumulators, and springs at their upper ends. One of these springs is connected with one of the lamp terminals, the other terminal being insulated and capable of being connected to the other pole of the battery by means of a needle which is introduced into a horizontal hole in the cover. The contacts being in the interior of the box, it is claimed that no explosion can be caused by its use, and that the lamp can be lighted or extinguished in an inflammable atmosphere. The apparatus weighs 1,800 grammes (about 4lb.), and gives on an average 12 hours of light at from ·7 to ·8 cp. (French).

Bradford Tramways.—Mr. Cox, the borough surveyor of Bradford, has drawn up a valuable report on tramways, with a view to the adoption of some other method of propulsion than steam, which he terms objectionable. He has visited Birmingham and Edinburgh, and is much impressed with the advantages of cable trams, though

the route on which it is proposed to introduce the system at Bradford is somewhat unsuitable. Still, he thinks the mechanical difficulties are not insurmountable. With regard to electric traction, he is of opinion that the Manningham-lane line would be a very good one on which to try experiments with an electric car, as the gradients compare favourably with the Birmingham line. He mentions that it is probable that the Electric Construction Corporation would be glad to lend a car for the experiment, and that the accumulators could be charged at the Bradford central station in Bolton-road. His statement that the car receipts at Birmingham are 20d. per car mile with electric as against 10d. with horse traction should have some influence with the Corporation when they consider his report.

Gravesend.—The Parliamentary Committee of the Gravesend Town Council have recommended the following special matter to be inserted in the advertisement of intention of applying for a provisional order for electric lighting: "That power be taken only to light the municipal borough of Gravesend, and that the compulsory area within which electric lines shall be laid down within a specified time shall be New-road, King-street, and Milton-road, from Queen-street to Trinity Church, High-street, Windmill-street, from King-street to Woodville-gardens, Railway-place, and Woodville-gardens. That the Corporation shall not propose to interfere with any streets not repairable by them, but that they shall take powers for crossing under or over the South-Eastern Railway, the London, Chatham, and Dover Railway, and the tramways." The committee also recommend that the highest maximum price to be charged by the local authority shall be inserted in the draft provisional order; that no electrician need be appointed by the Council, but that the borough surveyor be instructed to prepare the plans. These recommendations have been adopted.

City Lighting.—As will be seen in another column, the Commissioners of Sewers are advertising for tenders for lighting the western district of the City. This district comprises the area bounded on the north by the City boundary, on the east by Aldersgate-street, St. Martin's-le-Grand, St. Paul's-churchyard (north side), Creed-lane, and St. Andrew's-hill, and thence along Queen Victoria-street to Blackfriars Bridge; on the south by the Victoria Embankment, and on the west by the City boundary. The following are the main thoroughfares to be lighted: Holborn, Holborn Viaduct, Newgate-street, Charterhouse-street, King-street, Long-lane, Snow-hill, Chancery-lane, Fetter-lane, St. Andrew-street, Shoe-lane, St. Bride-street, Farringdon-street, New Bridge-street, Old Bailey, Fleet-street, Ludgate-hill, St. Paul's-churchyard (north side). A plan of the district will be found in our issue for April 19, 1889, p. 317 of Vol. III. As will be seen, the area to be lighted is a great centre of newspaper and book production, and the chances of obtaining private customers should be very good for the successful tenderer. Taking one thing with another, the lighting of the City seems at last to be in a fair way of becoming fact.

Dresden.—Three tenders have been sent in for the central electric station—by Messrs. Siemens and Halske, of Berlin; Schuckert and Co., of Nuremberg; and Kummer and Co., of Dresden—all of them proposing the adoption of continuous current, the two former with accumulators. For a capacity of 31,000 installed lamps (25,000 of them burning at the same time) the firm of Siemens and Halske propose three engines of 450 h.p., each driving three dynamos (each of 320,000 watts), for the sum of 2,060,507 marks (£103,025), including buildings and foundations. Messrs. Schuckert and Co. propose three engines of 300 h.p. each, and three dynamos, for 2,648,000 marks (£132,400), whilst Messrs. Kummer and Co. specify in their tender four steam engines of 290 h p. each, two engines of 580 h.p. each, and eight 78,750 as well as four 162,500 watts dynamos for the sum of about 3,000,000 marks (£150,000) with accumulator reserve, and 2,657,361 marks (£132,860) without same. Considering the low price of the tender and the care with which the specification has been prepared, the order for the erection of the central station has been placed with Messrs. Siemens and Halske, who expect to begin running in the winter of 1891-92.

Institution of Civil Engineers.—The council of the institution has issued a list of subjects on which it invites original communications during the ensuing session. The following more particularly concern our readers: The lighting of railway carriages by oil, gas, and electricity compared; electrical traction for roads and railways; the design and arrangement of electric supply stations, and of electric distributing apparatus, for domestic, trade, and general service in towns, particularly as to economy and safety; the comparative advantages of gas and electricity for lighting purposes; the application of electricity to bleaching; recent researches into the molecular properties of steel; the production of aluminium and its alloys, and their use for engineering purposes; electric mining machinery for pumping, hauling, and coal-cutting in mines and collieries; the application of electricity to smelting and metallurgical operations; the electro-deposition of copper; the laying out of engineering workshops; friction at different velocities, and the comparative value of different lubricants; the utilisation and distribution of water power; liquid-fuel motors, and their applications; the cost of the production and distribution of electrical energy; the distribution and application of electric power in towns; electrical-measuring instruments, such as ammeters, voltmeters, power-meters, and supply-meters.

Berlin.—We have frequently had occasion to call attention to the progress of electric lighting in Berlin. Here are a few recent statistics on the subject: Last year there were employed for the lighting of the Leipzigerstrasse 36 arc lamps, which were kept burning till midnight; while in the Unter den Linden there were 104 lamps, of which 56 were kept alight all night, the rest being extinguished at 12 o'clock. At the close of the year ending March 31st, the number of public establishments lighted by electricity was 450, as compared with 300 at the same date of the preceding year, or an increase of 150. In these there were 826 arc and 31,417 incandescent lamps, as against 540 arc and 23,016 incandescent lamps in 1887-8, an increase of 286 and 8,401. The number of private establishments lighted at the end of March last was 237, as compared with 189 for the previous year, an increase of 48. Gas engines were employed in 79 cases in driving dynamos, an advance of 26 on the preceding 12 months. There were 2,796 arc and 31,399 incandescent lamps in private establishments, as compared with 1,709 arc and 22,536 incandescent lamps in 1887-8, being a rise of 1,087 and 8,863 respectively. The following are the totals for the two years: Establishments lighted by electricity on March 31st, 1888, 489; ditto, on March 31st, 1889, 687—increase, 198. Total number of arc lamps in use at the above-mentioned periods, 2,249 and 3,622 — increase, 1,373; ditto of incandescent lamps, 45,552 and 62,816—

EFFICIENCY OF EDISON-HOPKINSON DYNAMO AND WILLANS CENTRAL VALVE ENGINE.

Various tests have been published from time to time of the efficiency of Messrs. Willans and Robinson's central valve engine, and the various types of dynamos with which they are combined. At a recent test made at Thames Ditton with a large Edison-Hopkinson dynamo, constructed by Messrs. Mather and Platt, of the Salford Iron Works, Manchester, a result has been obtained giving an efficiency superior to anything previously attained.

The results show an efficiency of engine and dynamo combined—*i.e.*, the ratio of the electrical power available for useful work outside the dynamo to the indicated power of the engine—of 86·7 per cent.

The following are the particulars of the engine and dynamo: Compound double-crank engine with low-pressure cylinders 14in. diameter, stroke 6in., to work with 120lb. steam pressure, driving direct an Edison-Hopkinson dynamo, constructed for an output of 110 volts, 475 amperes, at 430 revolutions per minute. The dynamo has a bar armature—Patent No. 4,884, 1886, John Platt, John Hopkinson, and Edward Hopkinson—and is shunt wound only, and is fitted with a commutator of hard drawn copper, with mica insulation, with four brushes on each rocking arm.

Resistance of magnets	16 ohms.
Resistance of armature	0·0055 „
I.H.P.	83·3
E.H.P.	72·2

Hence efficiency, 86·7 per cent.

Consumption of water per I.H.P. hour ...	21·6lb.
„ „ „ E.H.P. hour ...	25lb.

In the test made on this combination, both engine and dynamo were worked to a somewhat higher load than their normal or specified load, and this no doubt would to a slight extent favourably affect the efficiency. Another test was made on a similar combination working at its normal load, with the following results:

Resistance of armature	0·0058 ohms.
Resistance of magnets	15·6 „
I.H.P.	85·3
E.H.P.	70·0

Hence efficiency of 83·3 per cent.

The electrical losses in the first instance are—

Loss in magnet coils, 756 watts = 1·4 per cent.
Loss in armature ... 1,386 watts = 2·6 „

Hence electrical efficiency 96·0 per cent.

From this it follows that the loss in friction in the engine and dynamo combined is 10 per cent. of the indicated horse-power.

Messrs. Mather and Platt have constructed a large number of dynamos for combination with the Willans engine. Those referred to above are part of a number made to the order of Mr. Hargreaves for the City installations of Messrs. Spiers and Pond. Others of a considerably larger output are in progress for Messrs. Gatti's central station in the Strand, and for the Westminster Supply Corporation, Limited, installation.

Combined Edison-Hopkinson Dynamo and Willans Central Valve Engine.

THE WESTINGHOUSE SYSTEM AT SARDINIA STREET STATION.

About a year ago the English Westinghouse Electric Company handed over to the Metropolitan Electric Supply Company the Sardinia-street station, which they had partly fitted up with engines, dynamos, and apparatus on the Westinghouse system. Since that time the capacity of the station has been doubled, and the station is now one of the finest in the country. Both the mechanical and electrical details have been thoroughly worked out, and the enterpri-

The accuracy attained in this series is a fair specimen of the whole.

With these explanations we proceed to give the results in tabular form, showing the date, the values of n and c, and the resulting value of C. The wire by which the condenser was connected to the commutator, together with the commutator itself, had a certain capacity which was determnied in the same way, merely disconnecting the wire from the condenser. In the observations in December and June we found

$$a = 10\,d = 98730 \quad c = 28460 \quad n = 63{\cdot}9$$

whence the capacity of the wires is ·0000625 microfarads, while in August, after the apparatus had been set up afresh in a different position with new connecting wires, the value of c was 22,200 and the capacity ·0000799 microfarads; for the wires the values of c could be determined to about 1 per cent.

In the table the value of C has been corrected for the capacity of the wires.

TABLE I.—CONDENSER I.

Date.	Value c	Value n.	C in microfarads.	Mean of series.
Dec. 31, 1889..	14,762·5	31·95	·021025	
	7,372·3	63·90	·021016	·021020
	5,894·3	79·875	·021019	
May 20, 1890............	14,772·9	31·93	·021023	
	7,376·5	63·86	·021017	·021022
	5,896·4	79·825	·021025	
June 16, 1890	7,375·0	63·86	·021022	·021072
Aug. 27, 1890	14,745·9	31·939	·021038	
	7,364·8	63·879	·021027	
	5,888·4	79·849	·021030	·021032

Mean of the whole, ·021024 microfarads.

TABLE II.—CONDENSER II.

Date.	Value c.	Value n.	C in microfarads.	Mean of series.
Dec. 31, 1889...........	13,957·4	31·95	·022238	
	6,963·6	63·90	·022249	·022237
	5,575·1	79·875	·022225	
May 20, 1890........ ...	13,945·3	31·93	·022271	
	6,957·4	63·86	·022283	·022273
	5,568·2	79·825	·022266	
June 16, 1890	6,953·4	63·86	·022296	·022296
Aug. 27, 1890	13,774·6	31·939	·022523	
	6,878·6	63·879	·022515	·022519
	5,500·4	79·849	·022518	
Aug. 28, 1890	6,878·6	63·881	·022515	·022515

TABLE III., giving the capacity of two mica condensers for various frequencies of charge.

CONDENSER A.

Frequency.	June 12.	June 14.	June 16.	Mean.
21	·04885	·04886	...	·04886
32	·04883	·04884	...	·04884
64	·04868	·04868	·04864	·04867
80	...	·04859	...	·04859
		CONDENSER B.		
21	...	·09642	...	·09642
32	...	·09642	...	·09642
64	...	·09634	·09642	·09638

Taking the air condensers first the tables show that at any rate for frequencies between 32 and 80 per second, the time of charging has no effect on the capacity, while the individual observations in each series are within 1 in 2,000 of each other.

For condenser I. the observations at frequency 64 are in all the series the least, but this is not the case with condenser II.

The capacity of condenser I. shows no change between December, 1889, and June, 1890. The observations in August, 1890, are all rather greater than the earlier series, but the increase about 1 in 2,000 is almost within the error of the experiments. With regard to condenser II., there is an indication of a rise in its capacity all through. It will be remembered that we have already shown that the insulation resistance of II. is considerably less than that of I., but it is easy to see that this leak was not sufficient to account for the change, for if R be the resistance of the leak, then our approximate formula becomes

$$n\,\mathrm{C} + \frac{1}{\mathrm{R}} = \frac{a}{c\,d} \text{ instead of } n\,\mathrm{C} = \frac{a}{c\,d}$$

Now the current through the condenser when leaking most was about ·0002 E C, where E is the E.M.F. to which it is charged, and C the capacity of the condenser.

Thus the resistance of the leak is $\frac{1}{{\cdot}0002 \times \mathrm{C}}$ or $\cdot25 \times 10^{20}$ C.G.S. units, since the value of C is $\cdot02 \times 10^{-15}$. This resistance is 250,000 megohms.

Hence the correction to the capacity $= 1/n\,\mathrm{R} = {\cdot}0002 \times \mathrm{C}/n$, and this is far too small to affect us.

There is no doubt, then, that the capacity of II. altered during the experiments by about 1 per cent., and it will be necessary to take it to pieces and set it up again.

It will be remembered that, in the early part of August, the leak in II. was very great, and it seems probable that the steps taken to discover the cause of the leak have produced a change in capacity. The experiments on II. then serve merely to show that the capacity can be found by the rotating commutator method to a high degree of accuracy, while those on I. prove that an air condenser, of ·02 microfarad capacity, has been constructed, which has retained its capacity, unaltered, for the eight months between January, 1889, and August, 1890.

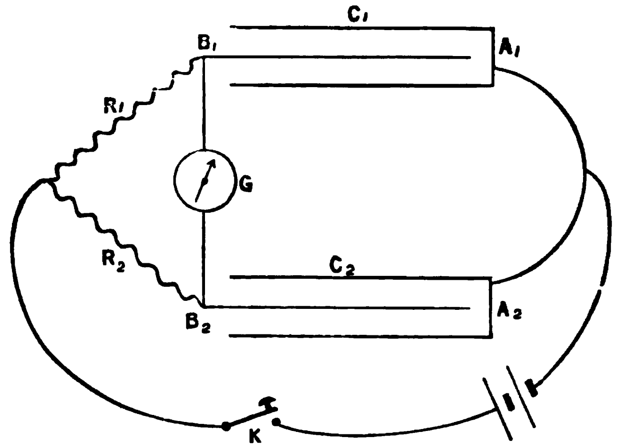


FIG. 5.

The effect of the leak in condenser II. was still further investigated on August 28th. The plates of II. were connected by a resistance of 30 megohms. Hence the correction to C, which is $-\frac{1}{n\,\mathrm{R}}$, becomes $- {\cdot}000520 \times 10^{-15}$, when $n = 64$.

The value of C found with the leak in was $\cdot023813 \times 10^{-15}$.

Hence, making the correction, C = ·02249 microfarads, which is sufficiently close to the value found without the artificial leak.

Table III. shows that with mica condensers not very much greater in capacity than the air condensers, a change in the frequency of the charge from 21 to 80, produces an appreciable change in the capacity; this, of course, is in consequence of the absorption. With large condensers, as we have already seen, the effect is more marked.

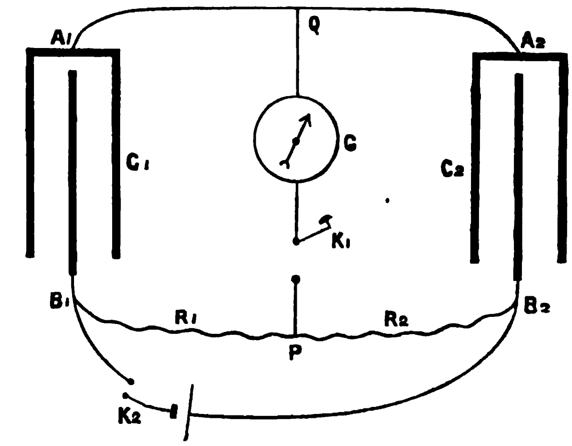


FIG. 6.

It remains, then, to give an account of the experiments undertaken for the purpose of comparing mica or paraffin condensers, as ordinarily used with the air condensers, and of investigating some of the effects of absorption.

The two well-known methods of De Sauty and Sir William Thomson have both been employed.

The arrangements are shown in Figs. 5 and 6.

The first of these is not really suitable for use in cases in which there is absorption, though with care a fairly accurate measure of the instantaneous capacity can be found. The resistances, R_1, R_2, can always be arranged so that the effect of the charge rushing into the air condenser shows itself, as a sharp kick of the spot of light—to the left, say—followed by a slower deflection in the other direction due to the absorption charge soaking into the mica or paraffin. The resistance for which this sharp kick practically disappears is fairly definite, and from it the instantaneous capacity can be found, while an observation of the resulting kick due to the absorption enables us to calculate the increase of capacity which arises from that cause. This can be done in various ways. The

simplest, perhaps, is to disconnect the condensers from the circuit, and replacing the mica condenser by a variable condenser of small capacity, observe the kick this produces in the galvanometer when charged with the same battery. From this the capacity to which the absorption is equivalent can be approximately calculated.

Thus a condenser of about ·1 microfarad was compared with Dr. Muirhead's three condensers combined. Taking C_2 R_2 to refer to the air condenser, we had

$$C_2 = \cdot 009506$$
$$R_2 = \cdot 898650 \text{ ohms.}$$

and with $R_1 = 89300$ there was a slight tremor to the left and a movement of three divisions to the right; on changing R_1 by 100 ohms the change in the motion of the spot was marked.

This gives for the instantaneous capacity $C_1 = \cdot 09550$, the value found by the commutator at frequency 64 was ·09543 microfarads.

To evaluate the five divisions the air condenser was disconnected and the mica condenser replaced by one of capacity ·001 microfarads; the kick observed was 4·8 divisions, while with 002 microfarads it was nine divisions, thus a kick of five divisions corresponds to about ·0011 microfarad capacity. Hence the capacity of the mica condenser, including the full effect of absorption, is ·0966 microfarads.

The second method, about to be described, in which the absorption effect is included, gave ·0965 microfarads.

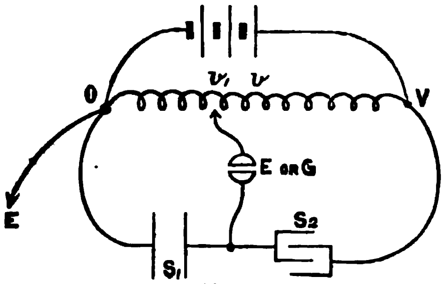


Fig. A.

Let us now consider the second method. The current from a battery flows through a large resistance, $R_1 + R_2$ B_1 P B_2 (Fig. 6). One plate of each condenser is in contact with B_1 and B_2 respectively, let V_1, V_2 be the potentials at these points. The other plates, A_1, A_2, are insulated and connected together, and to the galvanometer, G, the other pole of the galvanometer can be connected to P, through the insulated key, K_1. The galvanometer can be replaced by an electrometer. Let R_1 be the resistance, P_1 B, R_2 the resistance, P B_2. Suppose the point, P, be put to earth, the rest of the circuit being insulated. Then if C_1 C_2 be the capacities, it is easy to see that there will be no current through the galvanometer on making the key K_1, if $C_1 R_1 = C_2 R_2$.

Now, in the case of a mica or paraffin condenser the capacity is a function of the immediate past history of the condenser, and different values will be found for the R_1, R_2, according to the time the charging has lasted. Dr. Muirhead, however, who uses the method largely, has shown how to obtain the instantaneous capacity from the observations. His method is described in the following extract from a letter to myself. In the method as described, one pole of the battery is to earth instead of the point, P, of Fig. 6.

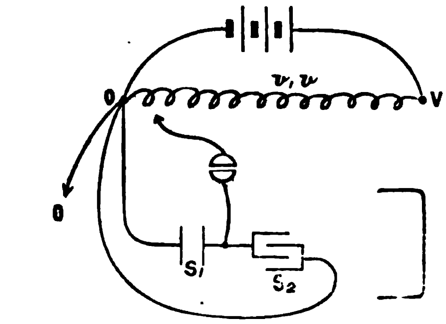


Fig. B.

Dr. Muirhead writes: "I have ·05 microfarad nearly in air condensers, and a series of mica condensers of ·1, ·2, ·3, ·331 (original 1/3) and ·498 (original ·5) mf. capacity, all enclosed in a double air-tight box to keep the temperature as uniform as possible. The capacity of these standards is determined periodically by both the tuning fork method (using a revolving commutator instead of the tuning fork), and by the ballistic galvanometer method. One can make comparison of these condensers among themselves and with other condensers by the method I adopt to an accuracy of 4 in 10,000. The temperature coefficient of shellacked mica condensers is about ·018 per degree C. and of paraffined mica 034 per cent.

Let S_1 be the capacity of the air condensers
„ S_2 „ „ „ condenser to be compared with air condensers.

After making battery contact, supposing the charging of the condensers to be instantaneous and the absorption *nil*, then we have

$$v S_1 = (V - v) S_2$$

where v is the potential of the junction of the two condensers. Should there be any delay in obtaining the balance, the position of v on the sides will vary—say to v_1—then the charges on the two condensers will be

$$v_1 S_1 \text{ and } (V - v_1)(S_2 + \sigma)$$

respectively, where σ is the apparent increase of capacity of S_2, due to absorption or soaking in of charge. On disconnecting the armature of S_2 from the slides and putting it to O, or earth, the potential falls from V to O, and immediately afterwards the potential of the junction of the two condensers becomes, say, v_2, so that

$$S_1 v_1 + S_2 (v_1 - V) = (S_1 + S_2) v_2$$

Hence

$$v_1 (S_1 + S_2) - V S_2 = (S_1 + S_2) v_2$$

or

$$S_2 = S_1 \cdot \frac{v_1 - v_2}{V - (v_1 - v_2)}$$

V and v_1 are known, and v_2 is indicated at once on an electrometer, or when a galvanometer is used it can be measured quickly thus: As soon as v_1 has been observed, break the galvanometer contact and move the index of the slides down to O, then directly after bringing the armature of S_2 from the full potential of the slides to zero, close the galvanometer circuit and observe the throw, a, which is a measure of v_2, the potential of the junction of the two condensers."

In my own experiments, which were made after consultation with Dr. Muirhead, I adopted a method practically the same as his; but before describing it, it will be better to consider rather more the effects of absorption. Let us suppose, at first, that the leakage from either condenser is inappreciable. If there be no absorption, each condenser is charged to its full potential practically instantaneously, and it does not matter when or in what order the keys, K_1, K_2, are put down, the position of P on the slide is not affected.

Suppose, now, that C_1 shows absorption, the capacity increases with the time of charging. We can get the instantaneous capacity by depressing, first, the key K_1 and then K_2, but in this case we are troubled with the effect of the slow after charging as in the other method. Still the resistance, for which the kick due to the initial charging disappears, is, with the condensers I employed, fairly marked, and a value for the instantaneous capacity can be thus fairly accurately obtained.

If, now, K_2 be made for 1 second and then K_1 depressed, a different position will be found for P. With this interval of charge the apparent capacity differs appreciably from its instantaneous value, and the after effects of the absorption can still be observed. The same is true for intervals of 2, 3, or 4 seconds, the value obtained for the capacity increases, and the after effect is still noticeable; but with the condensers and battery I used, if the time of charging was prolonged to 5 seconds, the after effect was inappreciable, and the position of P on the slide, and hence the apparent value of the capacity, were hardly affected by further increasing the time of charge. In the experiments on a cable recorded in Dr. Muirhead's paper already referred to, the absorption effects continue much longer. In the observations recorded below, then, unless the contrary is stated, the key K_2 was held down for five seconds, and then, K_1 being depressed, the position of P determined, for which the galvanometer remained unaffected. The value of the capacity deduced, then, is the full capacity for the potential to which the condenser is charged. It is of course possible, though further experiments would be wanted to prove it, that the full effect of absorption is not merely to increase by a definite amount, independent of the potential, the apparent instantaneous capacity, but that the increase may depend on the potential to which in each case the condenser is being charged. It will of course depend on the purposes for which the condenser is to be used whether the instantaneous capacity or the full capacity is required, and it probably will be best, when issuing certificates, to state both the instantaneous capacity and the maximum increase due to absorption—mentioning at the same time the potential used in the experiments for determining this correction, and also the time of charging in which this maximum increase is practically attained.

The method I employed in determining the correction due to absorption was the following: Suppose the plates, A_1, A_2, to be at potential zero and uncharged. Make the battery key, K_2, and after keeping it made for some little time break it again. If there be no absorption A_1 and A_2 will still be at zero potential and uncharged; but let there be absorption in one of the two, A_1, and let B_1 be the positive pole of the battery; then, while the battery is on, negative electricity is being absorbed by the dielectric near A_1, and positive electricity is left free over the plates, A_1, A_2, and the wires connecting them. When the battery is broken the negative electricity begins to soak out, but the process takes time. Hence, if immediately on breaking the battery key, K_2, the galvanometer key, K_1, is made for an instant, there is a throw of the galvanometer needle indicating the passage to the earth of the positive set free by the absorption. If, after a time, the galvanometer key be again depressed, there is an equal throw in the opposite direction caused by the passage of the negative which has again soaked out of the condenser. The required correction is obtained from either of these throws.

For, let i be the current between B^1 and B_2; let C_1 be the instantaneous capacity of the one condenser and C_2 of the other; and let Q be the quantity of electricity absorbed. Then the quantity of negative electricity on the plate A_1 is C_1 R_1, R_1, $i + Q$, and the quantity of positive electricity on the plate A_2 is $C_2 R_2 i$, if we assume the potential of these plates to be still zero.

Therefore,

$$C_1 R_1 i + Q = C_2 R_2 i.$$

$$\therefore \frac{C_1}{C_2} = \frac{R_2}{R_1} - \frac{Q}{C_2 R_1 i}.$$

If E be the E.M.F. of the battery, then neglecting the battery resistance

$$i=\frac{E}{R_1+R_2},$$

therefore
$$\frac{C_1}{C_2}=\frac{R_2}{R_1}-\frac{Q^1}{C_2 E}\left(1+\frac{R_2}{R_1}\right).$$

Now, we have seen that with the galvanometer as I used it, if γ is the throw produced by the passage of a quantity, Q, then $Q=\gamma\times 10^{-10}$.

The battery consisted of 36 storage cells, which, when fully charged, had an E.M.F. of about 75 volts, so that

$$E=75\times 10^{8}.$$

Also,
$$C_2=\cdot 021 \text{ microfarads}$$
$$=21\times 10^{-18}.$$

Hence, with these numbers,

$$\frac{C_1}{C_2}=\frac{R_2}{R_1}-\frac{\gamma}{1575}\left(1+\frac{R_2}{R_1}\right)$$

Or, writing it as a correction to C_1,

$$C_1=\frac{C_2 R_2}{R_1}-\frac{\gamma}{75}\left(1+\frac{R_2}{R_1}\right)10^{\cdot 18}.$$

Examples of the method of applying this correction will be given shortly.

It will be noticed that a leak in one of the condensers may be corrected for in the same way. For, suppose the mica condenser to leak, then a quantity of Q^1 of positive electricity passes through to the plate, A_1, while the battery current is on, and the condition that the galvanometer should not be deflected is

$$C_2 R_2 i - C_1 R_1 i = Q^1,$$

the same equation as previously.

There will, however, be this difference: on depressing the key, K, after breaking the battery circuit, a positive charge will in both cases pass from A to B through the galvanometer; if this charge be due to absorption, there will, when the key is again depressed after an interval, be a current through the galvanometer in the opposite direction; while if the first charge be due entirely to a leak, there will be no effect when the key is the second time depressed. In practice, the leak and the absorption may exist together either in the same or different condensers. In the second case the leak will tend to produce opposite effects to those caused by the absorption; the quantity, Q^1, however, increases nearly in the ratio of the time of charging, while Q increases for the first few seconds, but soon reaches a maximum and then remains constant.

These considerations are illustrated by some experiments in which the condensers I. and II. were compared with various mica condensers. The battery key was in each case made for 30 seconds. It was then broken, and the galvanometer key was made for an instant, the resulting throw was the sum of those due to (1) the leak in the mica condenser (λ), say, (2) the absorption in that condenser (a) say, and (3) the leak in the air condenser, which produces an effect in the opposite direction $-\lambda^1$, say.

After about 30 seconds more the key was again depressed, the resulting throw is due to the absorbed electricity which has again leaked out, and will give us $-a$.

The following table gives the results. Each observation entered is the mean of three or four.

Condenser compared with standard	—	I.	II.
·05	$\lambda+a-\lambda^1$	2·3	—7·3
	$-a$	—3	—2·6
·1	$\lambda+a-\lambda^1$	2·2	—9
	$-a$	—3	—3
·1	$\lambda+a-\lambda^1$	2·2	—7
	$-a$	—2·2	—3·5
·5	$\lambda+a-\lambda^1$	3·3	—4
	$-a$	—3·3	—2·5
·1	$\lambda+a-\lambda^1$	4	—3·2
	$-a$	—5	—5·7

If we take the comparisons with condenser I. first, it appears that throughout $\lambda-\lambda^1$ is small. For the ·05 and ·1 microfarad it may be about $-\cdot 5$ divisions, while a is about 3 divisions; for the ·5 microfarad a is rather larger, being about 3·3, and $\lambda-\lambda^1$ is zero, while for the 1 microfarad, a, the absorption effect is distinctly larger, being 5 divisions, and $\lambda-\lambda^1$ is about -1. All this is, of course, quite consistent with the fact that condenser I. and the mica condensers insulate well while there is absorption by the mica.

When, however, we come to the condenser II. the results are quite different. While the absorption effects are comparable, as, of course, they ought to be, with those obtained in the comparison with I., the leakage effects are very large.

The values of $\lambda-\lambda^1$ in order are as follows: -9, -12, $-10·5$, $-6·5$, -8. Now, we know that the mica condenser shows very little leak effect, the above leaks are therefore almost entirely in the air condenser II. If we suppose the total leak to be proportional to the time, then for the 5 second charges used in the experiments the corresponding values of γ in the corrections to be introduced for leakage will be 1/6 of the above, and thus we get the following results:

Condensers.	Value of.	Correction to capacity in microfarads for the leak.
·05	1·5	·00007
·1	2	·00016
·5	1	·0003
1·0	1	·0007

It is clear that the corrections are in all cases small, being not much over 1 in 1,000, but they serve to illustrate the method. The above corrections are only those for the leak, the correction for absorption could be found in the same way.

With a view to testing the method in a case in which a leak only existed without absorption, a number of comparisons of I. and II. were made.

In these experiments the resistance with I. was 296,240. The resistances with II. and the deflections due to the leak obtained by breaking the battery and then making the galvanometer, are given below, together with the ratio of the two capacities corrected for the leak.

Interval between battery and galvanometer contacts.	Resistance.	Leak in scale divisions.	$\frac{R_2}{R_1}$	Correction.	$\frac{C_2}{C_1}$
0"	275,980	0	1·0734	0	1·0734
5"	275,180	2·5	1·0765	—·0032	1·0733
30"	271,380	14·5	1·0916	—·0184	1·0732
60"	267,180	22·5	1·1088	—·0286	1·0802
5"	91,370	5	4·3223	·0168	4·3391
30"	92,670	22	4·2617	·0743	4·3360
60"	94,170	42	4·1938	·1415	4·3353

The last three lines of the table give the results of a series of comparisons between II., which had a leak, and a condenser of ·1 microfarad, which showed absorption. The resistance with II. was 394,930 ohms.

In the first four lines the corrections are negative, for the capacity of the leaky condenser is being found in terms of the standard. In the next three lines they are positive, for the ratio of the mica condenser to the leaky standard II. is being found.

A comparison of the fourth and sixth columns shows the results of the correction. In the fourth line it is clear that the correction is not large enough. This probably arises from the difficulty of making contact with the galvanometer circuit sufficiently soon after the battery is broken to ensure that the whole of the charge accumulated by the leak should pass through the galvanometer.

The leak correction was also tested with similar results by putting an artificial leak in I.

We will now give some specimens of the observations made to compare I. with the mica condenser in order to show the accuracy attained. Condenser I. compared with ·1 microfarad; resistance with I., 493,560 ohms; resistance with ·1 microfarad, 105,800 + a in ordinary variable resistance given below.

In the table in which the effect of the galvanometer is shown by the letters R, L, in the last column, R means there was a deflection to the right, L to the left.

Interval between galvanometer and battery contact.	Variable resistance to be added above.	Effect on galvanometer.
5"	700	R
	400	L
	500	Very small R
2	400	L
	700	R
	600	L
0"	1,200	L
	1,300	Tremor L, then swing to R.
	1,400	R

Thus in this case the effect of an alteration of 100 in the resistance, *i.e.*, $\frac{1}{1000}$ of the whole, is very marked, and we may take the following values for R:

5" interval .... 105,800 + 500
2" „ .... 105,800 + 650
0" „ .... 105,800 + 1,300

Other series of observations showed that the resistance for 10 seconds interval was the same as for 5 seconds; if the interval was prolonged to 30 seconds a very small increase in capacity was noticeable. Thus the effect of absorption is to increase the capacity of the ·1 microfarad by about 8 in 1,000, or ·008 of the whole, of this ·0065 shows itself in the first 2 seconds of charging and ·0015 afterwards, the increase after 5 seconds, if any, being extremely small.

When comparing I. with ·5 microfarad the resistances used were 592,290 and 24,910 respectively. In this case an alteration in the latter resistance of 10 ohms, or $\frac{1}{2490}$, was easily seen. The following are the results:

Interval.	Resistance.
10″	24,900
5″	24,900
2″	24,930
0″	25,060

Showing, again, that the absorption effect disappears after five seconds, and that the effect of absorption in two seconds is about ·0052, and in five seconds about ·0064 of the whole capacity.

When comparing with one microfarad the resistances were 592,290 and 12,580, the last number being accurate to about five ohms, or about the same proportion as before.

The results of the various observations are given in the following table, the observations made with II. have been corrected for the leak as already explained:

TABLE giving the capacities of certain mica condensers as compared with the air condensers.

Date.	Value from I.	Value from II.	Value found by commutator at frequency 64.
Aug. 19	·04934	·04938	·04867
23	·04934	·04936	—
June 17	·09772	·09780	·09638
Aug. 14	·09751	—	—
18	·09773	·09786	—
21	·09773	·09781	—
Aug. 18 (M)	·5005	·5008	—
18 (A)	·5007	·5009	—
21	·5006	·5010	—
Aug. 18	·9910	·9912	—
21	·9913	·9912	—

It will be noticed that for either condenser I. or II. the results are in very close accordance; with the exception of one observation, on August 14th, the differences are barely as great as 1 in 5,000, and the method is clearly capable of giving the value of a mica condenser in terms of the air condenser to this accuracy.

The reason for the low result on August 14th is to be found in the fact that on that day the leak in I. was considerable, being, as we have seen, over 1 per cent. per minute. Full observations for the correction were not taken; it would, however, amount to about ·0002 judged by the correction required to observations on II. when leaking at a similar rate.

The results from II. are equally consistent among themselves, but all slightly greater than those from I. This would indicate that the correction applied for in the leak in II. is rather too large.

The capacities given in the table are those found with a five seconds' interval, by which time, as we have seen, the absorption in the mica condensers used is practically complete. We have already discussed the method of determining the instantaneous capacity, and a table of the corresponding values could easily be given.

For our present purpose it is hardly necessary to do this, and, indeed, for many purposes for which condensers are employed, a knowledge of the full capacity is more useful than one of the instantaneous one. In the last column the values of the capacities found by the commutator method are given, the differences in both cases amount to about 1·3 per cent. of the capacity.

During the forthcoming year condenser II. will be again set up and tested, and the permanent arrangements for rapidly comparing condensers and for issuing certificates will, I hope, be completed.

GLASGOW CORPORATION TRAMWAYS.

REPORT BY THE SUB-COMMITTEE APPOINTED BY THE TRAMWAYS COMMITTEE ON 22ND AUGUST TO CONSIDER THE QUESTION OF WORKING THE TRAMWAYS BY ELECTRICAL OR OTHER MOTOR POWER, AND TO REPORT WHAT ACTION SHOULD BE TAKEN IN THE MATTER.

In compliance with the remit made to them, the sub-committee beg to report that they have made enquiry and examination regarding the most recent developments of tramway traction.

Cable and steam traction were investigated and reported upon under previous remits. Continued progress and improvement in the adaptation of both of these systems to the working of tramways have been made, but the sub-committee did not consider it expedient to renew investigation of these, although they embraced such opportunity as naturally presented itself of acquiring information relative to developments of these systems.

For the reason given, the sub-committee have at this time mainly directed their attention to electric traction. That form of traction is by no means new, but until recently it had not taken such shape as made its adoption on the streets of our towns a practical possibility. The electric force was conveyed by overhead wires or by a wire laid in a trough in the street or through the medium of the rail or other conductor, all of which had some objectional feature as applied to street tramways, but which for present purposes it is unnecessary to enter upon. Experimentalists were nevertheless at work endeavouring to devise a system whereby electrical energy, developed at a central station, might be stored in accumulators and applied to the working of motors on individual cars. No tramway company seemed to care to take up the perfecting of the work. The General Electric Power and Traction Company, Limited, however, set themselves towards the solution of the question, and have done so in a very practical manner. Under arrangement with the North Metropolitan Tramways Company, London, they, about 15 months ago, entered upon the working of over a mile of street tramway at Barking, a suburb of London, and undertook the running of cars thereon at a fixed charge, including drivers, but not conductors, of 4½d. per mile. For the performance of this obligation they erected a work for the generation of electric power and for the storage of cars near one of the termini, and since then they have continued to run a service of passenger cars on the road, over 100,000 miles having been run. Practical difficulties have been gradually overcome, till now there is little doubt of the successful issue of the experiment. The main point remaining to be solved is the life of the batteries or accumulators, and depending on that is the total expense of working the cars per mile run. However, the experience gained by the North Metropolitan Tramways Company in observing what the Electric Power Company has been able to accomplish, has led the tramway company to obtain parliamentary sanction to an extension of the system, subject to the approval thereof by the local authorities. The tramway company have accordingly applied to the local authorities for permission to use electric power on a further length of tramways; and contingent on such approval and the completion of arrangements with the Electric Power Company, the tramway company have resolved to extend the system of electric traction.

The sub-committee were much pleased with their visit to Barking. The tramway is a single line, 1¼ miles long, having loop lines or sidings for passing, and there are some steepish gradients and quick curves upon it, all of which are successfully overcome in the working. The weight of the car in running order is about six tons. They are evidently well patronised and appreciated by the public. There is a total absence of smell, vapour, or other nuisance; the machinery is entirely concealed under the car, the same power which propels the car also lights them electrically, and they are thus clean and well lighted. They have all the appearance of ordinary street cars, and we saw no instance of timidity or fear in the horses passing the same.

While such work has been going on in London, the Birmingham Central Tramway Company have proceeded further. That company are now and have been for nearly three months working the tramways extending from Birmingham along the Bristol-road to Bournbrook by electric power. The system is the same as is in use in London, but on a larger scale. The Birmingham company having been able to start with the experience obtained in London, their cars and machinery are more perfected than those in London. The Bristol-road tramway is a double line, three miles in length, on which a 15 minutes' service is given entirely by electric power. The service is about to be increased to a car every 10 minutes. Each car runs about 72 miles per day, the total daily run being now 360 miles. The speed is restricted by Board of Trade to eight miles an hour. One set of batteries run the car for one-half the day, and the changing of the batteries—which is done within the yard—occupies only some three or four minutes. There are stiffish gradients on the route, also some sharp curves, so that bogie cars have been adopted. The weight of this car in running order is about eight tons, and 50 passengers are carried. The motors seem capable of readily accomplishing all the work required of them, and on the car which was put at our service a speed of from 10 to 12 miles an hour was easily obtained.

The tramway company express themselves as thoroughly satisfied with their venture. Their drawings per car mile exceed those of the steam or cable-moved cars, which are owned and worked by the same company. The one point to be solved by them, prior to further extension of the system, is that of depreciation, and it is apparent that can be solved only by a continuance of practical work.

The Electric Power Company, whose agent was also present, said that that company was preparing to give guarantees to users of the batteries, and indicated such figures to us in respect of the cost and depreciation of the same, in the event of their general adoption on an extensive tramway system, as would leave no doubt of a successful issue of the working. As regards the Birmingham tramways, we would repeat all that has been already said as to the cleanliness, satisfactory electric lighting, freedom from smell, noise, or other unpleasantness on the electric cars. The cars seem to be well appreciated and well patronised, and, with a considerable vehicular traffic alongside, we did not observe any fear or timidity on the part of the horses.

In conclusion, we are of opinion that, having regard to the near termination of the lease of the Glasgow tramways, the end of which is the natural time for making a change in motive power, the time has come when application should be made to Parliament for authority to use electric and other power.

The sub-committee would therefore recommend that application be made in the ensuing session of Parliament for authority to work the Glasgow Corporation tramways by electric and other mechanical power, the present right of working by animal power being of course retained, and that a Bill should be prepared, and the requisite notice for same be duly given.

It will doubtless be that such authority would be granted, subject to the supervision and control of the Board of Trade, but to that there could be no objection.

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DETERIORATION.

Mr. Preece has had a hand in a good many reforms, and among other things has more than once touched upon questions of photometry. A settlement of this question is of some importance, especially when it is considered that local authorities entering into contracts with supply companies will undoubtedly check the candle-power contracted for with that actually supplied. This view of matters is amply confirmed by what has taken place at Leamington. In this town, as most of our readers are aware, is an electric light installation, supplying a part of the town with light for the streets. The lamps are mainly incandescent, and nominally should give a light of 16 candles. The contract is said to impose upon the supply company the supply of lamps of 16 c.p. The report of the Watch Committee to the Council states that during 14 days 80 of the electric lamps were tested, 22 of which were selected as bad, their average illuminating power being 10·2 candles. The remaining 58 taken haphazard gave an average illuminating power of 14·5 candles. Elsewhere will be found a report of the discussion on the subject by the Leamington Town Council, a discussion which ended with a motion to try and obtain back from the company money sufficient to recoup the town for previous overcharge, and to prevent such overcharge in future.

Electric light companies have had the good fortune in many cases to be treated very leniently in the way of contracts, but a more stringent interpretation of their clauses will gradually come into operation. Those who have to pay will insist upon getting what they pay for. This is but just and cannot well be objected to. However, it will affect supply companies in two ways. In the first place, there must be some definite system of photometry adopted, sanctioned by authority, that will prevent different people giving different values to the same light.

The more troublesome question relates to the deterioration of the lamps themselves. A lamp which, under pressure of the specified voltage, gives a satisfactory 16 candles when newly installed, soon begins to lose its candle-power. There are several causes of this decay, which are natural and always expected. Concerning ourselves for the moment about one only, the blackening of the bulb causes a loss. Now, if the contract has to be carried out strictly, the contractor must make provision against this loss. Assume that after a month's use the lamps at the specified voltage give an average of only 15 candles, then probably the voltage would be raised if any demand was made from the local authority to the supply company. The latter evidently cannot afford to replace lamps that are half or one candle too low in illuminating power; probably do not care to replace such as give an

average of 10·2 instead of 16, as at Leamington. Still, no purchaser cares to pay full price for light of which he receives only two-thirds. Of course no definite figures can be given as yet as to the time an ordinary lamp will give its normal candle-power under normal conditions. The whole field has to be worked out, but it is clear that lamp manufacturers have a responsibility that they really seem not to realise, and upon the commercial efficiency of their lamps depends much of the success of supply companies. It is not a question of a lamp lasting under normal pressure for a thousand hours, and selling for a couple of shillings: it is a question of its efficiency in normal candle-power lasting through the longest length of time. A lamp selling for two shillings, and giving 16 candles during 750 hours, under normal pressure, and then breaking, is better than a lamp that lasts under the pressure 2,000 hours, and gives only 500 hours normal candle-power. Fortunately, or unfortunately, the lamp manufacture in England is a monopoly. The monopolists have not acted in a manner to induce suggestions from any quarter, and it is a thankless task to attempt to serve their interests. No doubt extraordinary efforts will be made to extend the monopoly, but the opposition to this course will be so great as to render such a result impossible. It must be well understood that unless the lamps made are satisfactory to users, a score of makers will appear as soon as the patent rights expire. It should be the aim of the existing combination to make lamps so good that new competitors would have no chance to excel. Why do we insist that the lamp makers have to solve this problem? This is readily seen by considering that an installation is designed for a certain purpose. Dynamos are put down with engines to run a definite number of revolutions per minute, to give a certain pressure at that number of revolutions. The mains, fuses, etc., are designed to take their part in the system under these predetermined conditions. If now the lamps are expected to give 16 candles under 100 volts pressure, and for some reason or other, inherent to the lamps, the voltage has to be raised to 115 or 120 volts in order to obtain the 16 candles contracted for, then the whole system is strained in a manner for which it was not designed. While everything may be perfectly satisfactory, except the lamps in the normal state of running, the same may not happen under the excess demand. Unless lamps can be produced that will deteriorate very slowly, it will be necessary to start with lamps giving considerably more than the candle-power below which they are rejected. Thus if the contract is to give 16 candles with pressure 100 volts, it seems to us that lamps will have to be used that give, say, 20 candles with 100 volts and will gradually deteriorate down to 16 candles, always under pressure of 100 volts. The slower such deterioration takes place the better the lamp.

NORTHAMPTON.

Some of the supply companies no doubt reflect gloomily upon the mutability of affairs mundane. If we are to believe the local papers they have cause sometimes for reflection, especially when things electrical go awry, like the result of tendering at Northampton. The ordinary reading of the matter is that the authorities requested tenders to be sent in for certain work. Tenders were prepared and sent in by Messrs. Crompton and Co., the Brush Co., T. Brown and Co., Laing, Wharton, and Down, and Messrs. Rooper and Tozer. The committee to whom the tenders were submitted, certainly show that the wisdom of the serpent is not lacking at Northampton, for they considerately suggest the "Electric Light Co." be *requested* to do the work, *at a price not to exceed the average of the tenders* of the five firms above mentioned. This is very much on a par with the action of another local authority not long since commented on in these columns. The above firms have each spent a considerable sum in getting out tenders, in the natural expectation that the lowest bona fide tender would gain the work. At someone else's expense the authority has gained a fair idea of what the work should cost, and immediately gives the work to another company, and one which, so far as we gather, did not compete. Really, our views of how local authorities should transact their business is so diametrically the opposite to what has been described, that it is difficult to consider the matter as coming under the head of ordinary business. We prefer to look upon it as an extraordinary transaction, and one to be decried at every opportunity, and to be avoided as the plague. Such actions reduce the system of tendering to little better than a farce, and firms of repute will insist upon local authorities giving a guarantee as to the acceptance of a tender, if such proceedings are to rule generally. In this case the work is to be given, after reference back to the committee for assent, to a local company, a proceeding we endorse if the action is according to usual business custom. The local company, in this instance, is saved the expense of tendering, and also saved from cutting rates. It has the preeminent position of being in a safe place, for we hardly suppose a case exists where the average of five bona fide tenders does not allow a fair sum for good work, and a fair sum for profit. What have those companies which sent in tenders to say about the result? Are they satisfied? The Northampton authorities if they intended the work to go to a particular firm, ought to have obtained an estimate from a consulting engineer, asked the said firm to estimate, and negotiated the affair in the usual way.

LONDON TRAMWAYS.

As the politicians say, it is no good attempting legislation unless public opinion is in its favour. Well, public opinion has to be made, and one of the privileges of newspapers is to make it. Vestries and local boards, in many instances, have need to hear the expression of public opinion, for their actions sometimes bear the stamp of hastiness and inconsiderateness. Thus it seems to onlookers that the decision of the West Ham Local Board in relation to electric trams is, to say the least, hasty. The North Metropolitan Tramway Company, so we hear, is desirous of equipping a part of its system with 12 electric cars, at an expenditure approaching £20,000, but the West Ham Local Board refuse to grant more than a 12 months' license, and that to be terminated, so far as we can make out, by a 24 hours' notice. Now, no company can undertake a heavy expenditure subject to a 24 hours' notice. The question is to be discussed by the London County Council, when further light will be thrown on the matter, and it may again be referred to—meanwhile we in vain seek for reasons for the action of West Ham.

ORGANISATION OF COMPANIES' STAFFS.

In the efficient carrying out of electrical engineering work, the actual electrical part is not unfrequently one of the smallest of the whole work. The engineering part is often the larger; and the commercial and financial parts also of an electrical enterprise, if not essentially those in which an electrical engineer as such should concern himself, are yet organic parts of the framework of any scheme, which it is quite as well for the engineer who wishes to do his work efficiently to understand. Of these departments the organising of his staff is quite as important as the employment of the right materials, and is well worthy of special attention from the point of view of theoretical consideration of such arrangement. We are not aware that any papers dealing with this branch have been read or written in this country by electrical men, though of course it has received its attention from those—naturally not very numerous—who have originally to arrange the organisation of large companies and their staffs. A paper, dealing with this subject from the American standpoint, has been read a short while ago by Mr. E. J. Hall, before the meeting of the National Telephone Exchange Association. In the same way that the efficiencies of dynamos have been better understood and greatly raised since the introduction of diagrammatic curves, so Mr. Hall considers the proper scheming of a company organisation is better accomplished by previously making diagrams of the exact relations that should exist between the various departments and the employés. "Almost invariably the study of a diagram," he says, "brings out the defects or suggests changes for improving the efficiency of the force." He starts with the axiom that the amount of work to be efficiently done by one person is usually small, and the work must be arranged till each part receives its proper share of attention and supervision. From the central authority must be a direct line of control, and, no matter how many departments, this line must be kept in good working order. He illustrates this by the familiar analogy of the brain, feet, hand, mouth, and digestive organs, all working together to provide and digest a meal. This direct line he terms the "line of authority," and draws out a diagram showing this unbroken connection from shareholders, through board of directors and chairman, one way, to the secretary and his clerks; another way through general manager to general superintendent, to superintendents of equipment, construction, or supply, to foremen, detailed workmen, or detailed operators. The diagram thus made clearly shows the general manager as having no authority over the secretary, being in a different line of authority, and so forth; in case the same position is filled by one man the line still holds good, and he controls the second line by virtue of the second position. Each officer should, as far as possible, hire and discharge all for whose efficiency he is responsible. There must be no cross lines of authority, though there should be "lines of relation;" and understandings between departments can be readily tested by the fact whether such orders or understandings are efficiently carried out. It is no excuse for the construction manager to say that the equipment manager promised to run a cable and failed to do it. He took the responsibility by asking it to be done, and should know whether it would be done or not. In a bad organisation this cross shifting of responsibility is always found, and the blame should rest with the organiser rather than the organised. Another defect is the giving of verbal orders—a practice sure to result in confusion. Whenever possible, orders should be given in writing, brief and clear; and if anything is left to discretion this should, if possible, be so stated. Advice and suggestions should, on the other hand, be verbal. If verbal orders are given, no time should be lost by the employé in reducing them to writing. "No man can serve two masters"—but this is specially difficult to arrange in small companies. A diagram such as suggested will help to keep the tangled lines straight and obviate inconsistencies. Thus the work of the company must be organised, prepared, carried out, and maintained, and withal human nature must be consulted, personal pride and self-interest allowed for, faithful service and capacity rewarded, the ignorant educated, the idle punished, the vicious and incapable got rid of, and over all strict discipline, tempered with sympathy and kindness, must be maintained. A plan such as suggested, with specification of exact functions required, will often help the organisers to better realise this ideal.

THE CROCKER-WHEELER MOTOR.

This motor is constructed for use with small currents on central station circuits. It is made from $\frac{1}{8}$ to 3 h.p., and can be put in either arc or incandescent circuits. There should be a great demand for just such a motor as this, and, as a matter of fact, it has met with ready adoption in the United States, where over 2,000 have been fitted up in one year. The details of construction have been carefully thought out, with a view to affording efficiency combined with compactness and durability.

The Crocker-Wheeler Motor.

We have often insisted on the value to central stations of supplying power as well as light, and motors of this sort appear to be likely to realise our ideas on the subject. We give an illustration of the machine, for which the General Electric Co., of 71, Queen Victoria-street, E.C., are the sole agents.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

LECTURE II.

GENERAL PRINCIPLES OF DESIGN AND CONSTRUCTION.—PRINCIPLE OF THE MAGNETIC CIRCUIT.

To-night we have to discuss the law of the magnetic circuit in its application to the electromagnet, and, in particular, to dwell upon some experimental results which have been obtained from time to time by different authorities as to the relation between the construction of the various parts of an electromagnet, and the effect of that construction on its performance. We have to deal not only with the size, section, length, and material of the iron cores, and of the armatures of iron, but we have to consider also the winding of the upper coil, and its form; and we have to speak in particular about the way in which the shaping of the core and of the armature affects the performance of the electromagnet in acting on its armature, whether in contact or at a distance. But before we enter on the last more difficult part of the subject, we will deal solely and exclusively with the law of force of the magnet upon its armature when the two are in contact with one another; in other words, with the law of traction.

I alluded in a historical manner in my first lecture to the principle of the magnetic circuit, telling you how the idea had gradually grown up, perforce, from a consideration of the facts. The law of the magnetic circuit was, however, first thrown into shape in 1873 by Prof. Rowland, of Baltimore. He pointed out that if you consider any simple case, and find (as electricians do for the electric circuit) an expression for the magnetising force which tends to drive the magnetism round the circuit, and divide that by the resistance to magnetisation reckoned also all round the circuit, the quotient of those two gives you the total amount of flow or flux of magnetism; that is to say, one may calculate the quantity of magnetism that passes in that way round the magnetic circuit in exactly the same way as one calculates the strength of the electric current by the law of Ohm. Rowland, indeed, went a great deal further than this, for he applied this very calculation to the experiments made by Joule more than 30 years before, and from those experiments deduced the degree of magnetisation to which Joule had driven the iron of his magnets, and by inference obtained the amount of current that he had been causing to circulate. Now, this law requires to be written out in a form that can be used for future calculation. To put it in words without any symbols, we must first reckon out from the number of turns of wire in the coil, and the number of amperes of current which circulates in them, the whole magneto-motive force—the whole of that which tends to drive magnetism along the piece of iron—for it is, in fact, proportional to the strength of the current and the number of times it circulates. Next, we must ascertain the resistance which the magnetic circuit offers to the passage of the magnetic lines. I here avowedly use Joule's own expression, which was afterwards adopted by Rowland, and, for short, so as to avoid having four words, we may simply call it the magnetic resistance. Mr. Heaviside has suggested as an advisable alternative term magnetic reluctance, in order that we may not confuse the resistance to magnetism in the magnetic circuit with the resistance to the flow of current in an electric circuit. However, we need not quarrel about terms. Magnetic reluctance is sufficiently expressive. Then having found these two, the quotient of them gives us a number representing—I must not call it the strength of the magnetic current—I will call it simply the quantity or number of magnetic lines which flow round the circuit; or if we could adopt a term which is used on the Continent, we might call it simply the magnetic flux; the flux of magnetism being the analogue of the flow of electricity in the electric law. The law of the magnetic circuit may then be stated as follows:

$$\text{Magnetic flux} = \frac{\text{magneto-motive force}}{\text{reluctance}}.$$

However, it is more convenient to deal with these matters in symbols, and therefore the symbols which I use, and have long been using, ought to be explained to you. For the number of spirals in a winding I use the letter S; for the strength of current, or number of amperes, the letter i; for the length of a bar, or core, I am going to use the letter l; for the area of cross-section, the letter A; for the permeability of the iron which we discussed in the last lecture, the Greek symbol μ; and for the total magnetic flux, the number of magnetic lines, I use the letter N. Then our law becomes as follows:

$$\text{Magneto-motive force } \frac{4\pi S i}{10};$$

$$\text{Magnetic reluctance } \Sigma \frac{l}{A\mu};$$

$$\text{Magnetic flux} \ldots\ldots\ldots \; N = \frac{\dfrac{4\pi S i}{10}}{\Sigma \dfrac{l}{A\mu}}.$$

If we take the number of spirals and multiply by the number of amperes of current, so as to get the whole amount of circulation of electric current expressed in so many ampere-turns, and multiply by 4π, and divide by 10, in order to get the proper unit (that is to say, multiply it by 1·257), that gives us the magneto-motive force. For magnetic reluctance, calculate out the reluctance exactly as you would the resistance of an electric conductor to the flow of electricity, or the resistance of a conductor of heat to the flow of heat; it will be proportional to the length, inversely proportional to the cross-section, and inversely proportional to the conductivity, or, in the present case, to the magnetic permeability. Now, if the circuit is a simple one, we may simply write down here the length, and divide it by the area of the cross-section and the permeability, and so find the value of the reluctance. But if the circuit be not a simple one, if you have not a simple ring of iron of equal section all round, it is necessary to consider the circuit in pieces as you would an electric circuit, ascertaining separately the reluctance of the separate parts, and adding all together. As there may be a number of such terms to be added together, I have prefixed the expression for the magnetic reluctance by the sign, Σ, of summation. But it does not by any means follow because we can write a thing down as simply as that that the calculation out of it will be a very simple matter. In the case of magnetic lines we are quite unable to do as one does with electric currents to insulate the flow. An electric current can be confined (provided we do not put it in at 10,000 volts pressure, or anything much bigger than that) to a copper conductor by an adequate layer of adequately strong—and I use the word "strong" both in a mechanical and electrical sense—of adequately strong insulating material. There are materials whose conductivity for electricity as compared with copper may be regarded perhaps as millions of millions of millions of times less; that is to say, they are practically perfect insulators. There are no such things for magnetism. The most highly-insulating substance we know of for magnetism is certainly not 10,000 times less permeable to magnetism than the most highly-magnetisable substance we known of, namely, iron in its best condition; and when one deals with electromagnets where curved portions of iron are surrounded with copper, or with air, or other insulating material, one is dealing with substances whose permeability, instead of being infinitely small, compared with that of iron, is quite considerable. We have to deal mainly with iron when it has been well magnetised. Its permeability compared with air is from 1,000 to 100 roughly; that is to say, the permeability of air compared with the iron is not less than from $\frac{1}{100}$th to $\frac{1}{1000}$th part. That means that it is quite possible to have a very considerable leakage of magnetic lines from iron into air occurring to complicate one's calculations, and prevent an accurate estimate being made of the true magnetic reluctance of any part of the circuit. Suppose, however, that we have got over all these difficulties, and made our calculations of the magnetic reluctance; then dividing the magneto-motive force by the reluctance gives us the whole number of magnetic lines.

There, then, is in its elementary form the law of the magnetic circuit stated exactly as Ohm's law is stated for electric circuits. But as a general rule one requires this magnetic law for certain applications, in which the problem is not to calculate from those two quantities what the total of magnetic lines will be. In most of the cases a rule is wanted for the purpose of calculating back. You want to know how to build a magnet so as to give you the requisite number of magnetic lines. You start by assuming that you need to have so many magnetic lines, and you require to know what magnetic reluctance there will be, and how much magneto-motive force will be needed. Well, that is a matter precisely analogous to those which every electrician comes across. He does not always want to use Ohm's law in the way in which it is commonly stated, to calculate the current from the E.M.F. and the resistance; he often wants to calculate what is the E.M.F. which will send a given current through a known resistance. And so do we. Our main consideration to-night will be devoted to the question how many ampere-turns of current circulation must be provided in order to drive the required quantity of magnetism through any given magnetic reluctance. Therefore, we will state our law a little differently. What we want to calculate out is the number of ampere-turns required. When once we have got that it is easy to say what the copper wire must consist of; what sort of wire, and how much of it. Turning, then, to our algebraic rule, we must transform it, so as to get all the other things besides the ampere-turns, to the other side of the equation. So we write the formula—

$$S\,i = \frac{N \cdot \Sigma \dfrac{l}{A\mu}}{1{\cdot}257}$$

We shall have then the ampere-turns equal to the number of magnetic lines we are going to force round the circuit multiplied by the sum of the magnetic reluctances divided by 1·257. Now this number, 1·257, is the constant that comes in when the length, l, is expressed in centimetres, the area in square centimetres, and the permeability in the usual numbers. Many persons unfortunately—I say so advisedly because of the waste of brain labour that they have been compelled to go through—prefer to work in inches and pounds and feet. They have, in fact, had to learn tables instead of acquiring them naturally without any learning. If the lengths be specified in inches, then the constant is a little different. The constant in that case for inches and square inch measures is 0·3132, so that the formula becomes

$$S\,i = N \times \Sigma \frac{l''}{A''\mu} \times 0{\cdot}3132.$$

Here it is convenient to leave the law of the magnetic circuit, and come back to it from time to time as we require. What I want to point out before I go to any of the applications is that, with the guidance provided by this law, one after another the various points that come under review can be arranged and explained, and that there does not now remain—if one applies this

* Cantor lectures, delivered before the Society of Arts.

inch. This shall be our practical rule: let us at once take an example. If you want to design an electromagnet to carry a load of one ton, divide the ton, or 2,240lb., by 150, and that gives the requisite number of square inches of wrought iron, namely, 14·92, or, say, 15. Of course one would work with a horseshoe-shaped magnet, or something equivalent—something with a return circuit—and calculate out the requisite cross-section, so that the total area exposed might be sufficient to carry the given load at 150lb. to the square inch. And, as a horseshoe magnet has two poles, the cross-section of the bar of which it is made must be 7½ square inches. If of round iron, it must be about 3½in. in diameter; if of square iron, it must be 2¾in. each way.

That settles the size of the iron, but not the length. Now the length of the iron, if one only considers the law of the magnetic circuit, ought to be as short as it can possibly be made. Reflect for what purpose we are designing. The design of an electromagnet is to be considered, as every design ought to be, with a view to the ultimate purpose to be served by that which you are designing. The present purpose is the actual sticking on of the magnet to a heavy weight, not acting on another magnet at a distance, not pulling at an armature separated from it by a thick layer of air; we are dealing with traction in contact. The question is, How long a piece of iron shall we need to bend over? The answer is, Take length enough, and no more than enough, to permit of room for winding on the necessary quantity of wire to carry the current which will give the requisite magnetising power. But this latter we do not yet know; it has to be calculated out by the law of the magnetic circuit. That is to say, we must calculate the magnetic flux and the magnetic reluctance as best we can; then from these calculate the ampere-turns of current, and from this calculate the needful quantity of copper wire, so arriving finally at the proper length of the iron core. It is obvious the cross-section being given, and the value of B, being prescribed, that settles the whole number of magnetic lines, N, that will go through the section. It is self-evident that length adds to the magnetic reluctance, and, therefore, the longer the length is, the greater have to be the number of ampere-turns of circulation. Therefore you should design the electromagnet as stumpy as possible—that is to say, make it a stumpy arch, even as Joule did when he came across the same problem, and arrived by a sort of scientific instinct at the right solution. You should have no greater length of iron than is necessary in order to get the windings on. Then, you see, we cannot absolutely calculate the length of the iron until we have an idea about the winding, and we must settle, therefore, provisionally, about the windings. Take a simple ideal case. Suppose we had an indefinitely long, straight iron rod, and we wound that from end to end with a magnetising coil. How thick a coil, how many ampere-turns of circulation per inch length, will you require in order to magnetise up to any particular degree? It is a matter of very simple calculation. You can calculate exactly what the magnetic reluctance of an inch length of the core will be. For example, if you are going to magnetise up to 16,000 lines per square centimetre, the permeability will be 320. You can take the area anything you like, and consider the length of 1in.; you can therefore calculate the magnetic reluctance per inch of conductor, and then you can at once say how many ampere-turns per inch would be necessary in order to give the desired indication of 16,000 magnetic lines to the square centimetre. And knowing the properties of copper wire, and how it heats up when there is a current; and knowing also how much heat you can get rid of per square inch of surface, it is a very simple matter to calculate what minimum thickness of copper the fire insurance companies would allow you to use. They would not allow you to have too thin a copper wire, because if you provide an insufficient thickness of copper, you still must drive your amperes through it to get a sufficient number of ampere-turns per inch of length; and if you drive those amperes through copper winding of an insufficient thickness the copper wire will overheat, and your insurance policy will be revoked. You therefore are compelled, by the practical consideration of not overheating, to provide a certain thickness of copper wire winding. I have made a rough calculation for certain cases, and I find that for such small electromagnets as one may ordinarily deal with, it is not necessary in any practical case to use a copper wire winding, the total thickness of which is greater than about half an inch; and, as a matter of fact, if you use as much thickness as half an inch, you need not then wind the coil all along, for if you will use copper wire winding, no matter what the size, whether thin or thick, so that the total thickness of copper outside the iron is half an inch, you can without overheating, using good wrought iron, make one inch of winding do for 20in. length of iron. That is to say, you do not really want more than $\frac{1}{40}$th of an inch of thickness of copper outside the iron to magnetise up to the prescribed degree of saturation that indefinitely long piece of which we are thinking, without overheating the outside surface in such a way as to violate the insurance rules. Take it approximately, if you wind to a thickness of half an inch, the inch length of copper will magnetise 20 inches length of iron up to the point where B equals 16,000. If, then, we have a bar bent into a sort of horseshoe in order to make it stick on to a perfectly-fitting armature also of equal section and quality, we really do not want more than one inch along the inner curve for every 20 inches of iron. An extremely stumpy magnet, such as I have sketched in Fig. 23, will therefore do if one can only get the iron sufficiently homogeneous throughout. If instead of crowding the wire near the polar parts we could wind entirely all round the curved part, though the layer of copper winding would be half an inch thick inside the arch, it would be much less outside. Such a magnet, provided the armature fitted with perfect accuracy to the polar surfaces, and provided a battery were arranged to send the requisite number of amperes of current through the coils, would pull with a force of one ton, the iron being but 3½in. in diameter. For my own part, in this case I should prefer not to use round iron, one of rectangular section being more convenient, but the round iron would take less copper in winding, as each turn would be of minimum length if the section were circular.

Now, this sort of calculation requires to be greatly modified directly one begins to deal with any other case. A stumpy short magnetic circuit with great cross-section is clearly the right thing for the greatest traction. You will get the given magnetisation and traction with the least amount of magnetising force when you have the area as great as possible, and the length as small as possible. You will kindly note that I have given you as yet no proofs for the practical rules that I have been using; they must come later. Also, I have said nothing about the size of the wire, whether thick or thin. That does not in the least matter; for the ampere-turns of magnetising power can be made up in any desired way. Suppose we want on any magnet 100 ampere-turns of magnetising power, and we choose to employ a thin wire that will only carry half an ampere, then we must wind 200 turns of that thin wire. Or, suppose we choose to wind it with a thick wire that will carry 10 amperes, then we shall want only 10 turns of that wire. The same weight of copper, heated up by the corresponding current to an equal degree of temperature, will have magnetising power when wound on the same core. But the rules about winding the copper will be considered later.

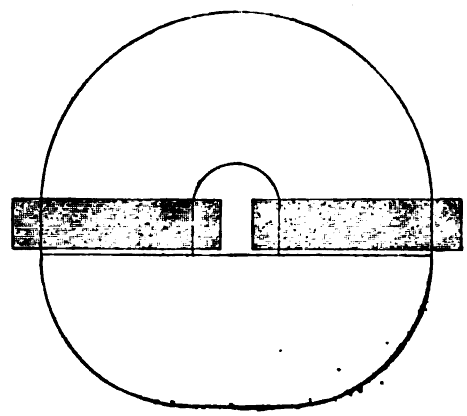


Fig. 23.—Stumpy Electromagnet.

Now if you look in the text-books that have been written on magnetism for information about the so-called lifting power or portative force of magnets—in other words, their traction—you will find that from the time of Bernoulli downwards, the law of portative force has claimed the attention of experimenters, who one after another have tried to give the law of portative force in terms of the weight of the magnets, usually dealing with permanent magnets, not electromagnets. Bernoulli gave a rule something of the following kind, which is commonly known as Häcker's rule:

$$P=a\sqrt[\frac{3}{2}]{W};$$

where W is the weight of the magnet, P the greatest load it will sustain, and a a constant depending on the unit of weight chosen, on the quality of the steel, and on its goodness of magnetisation. If the weights are in pounds then a is found, for the best steels, to vary from 18 to 24 in magnets of horseshoe shape. This expression is equivalent to saying that the power which a magnet can exert—he was dealing with steel magnets; there were no electromagnets in Bernoulli's time—is equal to some constant multiplied by the three-halfth root of the weight of the magnet itself. The rule is accurate only if you are dealing with a number of magnets all of the same geometrical form, all horseshoes, let us say, of the same general shape, made from the same sort of steel similarly magnetised. In former years I pondered much on Häcker's rule, wondering how on earth the three-halfth root of the weight could have anything to do with the magnetic pull; and having cudgelled my brains for a considerable time, I saw that there was really a very simple meaning in it. What I arrived at was this. If you are dealing with a given material, say hard steel, the weight is proportional to the volume, and the cube root of the volume is something proportional to the length, and the square of the cube root forms something proportional to the square of the length, that is to say, to something of the nature of a surface. What surface? Of course the polar surface. This complex rule, when thus analysed, turns out to be merely a mathematician's expression of the fact that the pull for a given material magnetised in a given way is proportional to the area of the polar surface; a law which in its simple form Joule seems to have arrived at naturally, and which in this extraordinarily academic form was arrived at by comparing the weights of magnets with the weight which they would lift. You will find it stated in many books that a good magnet will lift 20 times its own weight. There never was a more fallacious rule written. It is perfectly true that a good steel horseshoe magnet weighing 1lb. ought to be able to pull with a pull of 20lb. on a properly-shaped armature. But it does not follow that a magnet which weighs 2lb. will be able to pull with a force of 40lb. It ought not to, because a magnet that weighs 2lb. has not poles twice as big if it is the same shape. In order to have poles twice as big you must remember that three-halfth root coming in. If you take a magnet that weighs eight

times as much, it will have twice the linear dimensions and four times the surface; and with four times the surface in a magnet of the same form, similarly magnetised, you will have four times the pull. With a magnet eight times as heavy you will have only four times the pull. The pull, when other things are equal, goes by surface, and not by weight, and therefore it is ridiculous to give a rule saying how many times its own weight a magnet will pull. It is also narrated as a very extraordinary thing that Sir Isaac Newton had a magnet, a lodestone, which he wore in a signet-ring, which would lift 234 times its own weight. I have had an electromagnet which would lift 2,500 times its own weight, but then it was a very small one, and did not weigh more than a grain and a half. When you come to small things, of course the surface is large proportionately to the weight; the smaller you go, the larger becomes that disproportion. This all shows that the old law of traction in that form was practically valueless, and did not guide you to anything at all, whereas the law of traction as stated by Maxwell and explained further by the law of the magnetic circuit, proves a most useful rule.

From this digression let us return to the law of the magnetic circuit. I gave you in my first lecture, when speaking of permeability, the following rule for calculating the magnetic induction B: Take the pull in pounds, and the area of cross-section in square inches, divide one by the other, and take the square root of the quotient; then multiplying by 1,317 gives B; or multiplying by 8,494 gives B''. We have therefore a means of stepping from the pull per square inch to B'', or from B'' to the pull per square inch. Now the other rule of the magnetic circuit also enables us to get from the ampere-turns down to B'', for we have the following expression for the ampere-turns:

$$Si = N \times \Sigma \frac{l''}{A''\mu} \times 0{\cdot}3132,$$

and N the whole number of magnetic lines in the magnetic circuit is equal to B'' multiplied by A'', or

$$N = B'' A''.$$

From these we can deduce a simple direct expression, provided we assume the quality of iron as before, and also assume that there is no magnetic leakage, and that the area of cross-section is the same all round the circuit, in the armature as well as in the magnet core. So that l'' is simply the mean total path of the magnetic lines all round the closed magnetic circuit. We may then write

$$Si = \frac{B'' l''}{\mu} \times 0{\cdot}3132;$$

whence

$$B'' = \frac{\mu \times Si}{l'' \times 0{\cdot}3132}.$$

But by the law of traction, as stated above,

$$B'' = 8{,}494 \sqrt{\frac{P\,(\text{lbs.})}{A\,(\text{sq. in.})}}$$

Equating together these two values of B'', and solving, we get for the requisite number of ampere-turns of circulation of exciting currents:

$$Si = 2{,}661 \times \frac{l''}{\mu} \times \sqrt{\frac{P\,(\text{lbs.})}{A\,(\text{sq. in.})}}.$$

This, put into words, amounts to the following rule for calculating the amount of exciting power that is required for an electromagnet pulling at its armature, in the case where there is a closed magnetic circuit with no leakage of magnetic lines. Take the square root of the pounds per square inch; multiply this by the mean total length (in inches) all round the iron circuit; divide by the permeability (which must be calculated from the pounds per square inch by help of Table VI. and Table II.); and finally multiply by 2,661. The number so obtained will be the number of ampere-turns. One goes then at once from the pull per square inch to the number of ampere-turns required to produce that pull in a magnet of given length and of the prescribed quality. In the case where the pull is specified in kilogrammes, the area of section in square centimetres, and the length in centimetres, the formula becomes:

$$Si = 3{,}951 . \frac{l}{\mu}\sqrt{\frac{P}{A}}.$$

As an example, take a magnet core of round annealed wrought iron, ½in. in diameter, 8in. long, bent to horseshoe shape. As an armature, another piece, 4in. long, bent to meet the former. Let us agree to magnetise the iron up to the pitch of pulling with 112lb. to the square inch. Reference to Table VI. shows that B will be about 90,000, and Table II. shows that in that case μ will be about 907. From these data calculate what load the magnet will carry, and how many ampere-turns of circulation of current will be needed.

Ans.—Load (on two poles) = 43·97lb.
Ampere-turns needed = 372·5.

N.B.—In this calculation it is assumed that the contact surface between armature and magnet is perfect. It never is; the joint offers additional resistance to the magnetic lines, and there will be some leakage. It will be shown later how to estimate these effects, and to allow for them in the calculations.

(To be continued.)

THE PRENTICE DYNAMO.

The accompanying illustration shows a perspective view of a dynamo made by Mr. Napier Prentice, of Stowmarket, Suffolk. The armature is of the Pacinotti type, but the iron projections are so proportioned to the remainder of the armature, that it is claimed the greatest magnetic density is obtained without heating. The armature plates, which are cut from the softest charcoal iron, are punched with hexagonal holes in the middle, so that each plate is mechanically driven by the hexagon on the cast-steel shaft. The maker states that the magnetic density is so great that at the slow speed of 500 revolutions only a few turns of wire are required on the armature, and that this enables a high electrical efficiency to be obtained. What is termed the most important feature of the dynamo is the way in which all the wires are protected from injury by moisture or dirt. This is effected in the armature by means of metal cases arranged at each end, thus covering and enclosing the wires and commutator connections, and by strips of fibre placed over the wires, and filling up the spaces between the iron projections on the circumference. The protection of the field magnet coils is obtained by zinc cases soldered on to the metal flanges at each end of the coil. The commutator is built upon an iron quill, and the dynamo is said to run at full load without sparking, and the weight of the machine to be small. A 50-light Prentice dynamo is shown driving a ½-h.p. motor which actuates a corn-screener at the Brewers' Exhibition now being held at the Agricultural Hall.

The Prentice Dynamo.

OLD STUDENTS' ASSOCIATION.

The Old Students' Association of the City and Guilds of London Institute held their sixth annual dinner on Friday, October 17, at the Holborn Restaurant, Dr. W. E. Sumpner, the president, presiding. Of course, the dinner may be termed the principal work of the evening, but the Old Students, like every other English institution, take the opportunity of expressing opinions upon various subjects by means of toasts and replies. Our readers may assume, then, the dinner to have passed off satisfactorily, and the toast list commenced with the usual toast of the Queen.

Mr. A. Reckenzaun then proposed "The City and Guilds of London Institute." He said: To me has been given the honour of wishing success to the already eminently successful City and Guilds Institute. What better proof can we have of the immense advantages conferred by this institute than in the fact

that a large percentage of old students are now occupying leading positions in the various trades taught at the colleges connected with the City Guilds—and these, we all know, are scarcely in the teens of their existence? Another proof is in their great popularity; the demand, using a commercial expression, has long exceeded the supply, and still they come knocking at the portals of the temple of knowledge, often, unfortunately, to be refused admission. The Finsbury College is overcrowded—it has been so almost from the first. I remember, two years ago, asking Dr. Thompson, as a special favour, to admit the son of a friend of mine; but the Doctor, in his kind genial way, explained that it was entirely out of his power to accede to my request, as he had already refused scores of applicants. Last Monday week I attended one of the lectures of Dr. Thompson on electric meters. I arrived early, yet every seat was occupied, and I made myself comfortable on one of the steps; every inch of that lecture-room was monopolised by students, old and young, eager to imbibe knowledge. At the Central Institution, Dr. Sumpner informs me, 30 out of 100 candidates, who came up for the entrance examinations, had to be turned away. All this points to the great utility of the colleges; it also points to the growing appreciation of technical education in this country. I often think of the days when I first came to London, some 18 years ago, and obtained employment in one of the largest engineering works in the East-end. It was in the days when the School Board was in its infancy, when elementary education was not yet compulsory, in the days when technical schools for the masses were scarcely thought of except by the South Kensington Science and Art Department. In those days I came across many skilled mechanics who were almost illiterate, who could scarcely understand a working drawing except by the constant help of the foreman, yet these men were highly skilled in the use of tools; they produced excellent work. It seemed to me marvellous that this should be so, and after continued association with these men, I came to the conclusion that the British mechanic had natural gifts which my own compatriots in Austria did not possess to the same degree. The ingenuity which some of these British workmen displayed often astonished me. Without the slightest knowledge of Euclid or geometry, they lined out pieces of machinery correctly, without even the rudiments of theoretical mechanics these men arrived at logical conclusions. The British engineer, it seemed to me, was born, not made; he appeared to do most things intuitively, although in many cases he only succeeded by sheer perseverance after a long struggle in a roundabout way, and I often thought that if those clever fellows had had the advantage of some technical education combined with their natural abilities the foreigner would always have lagged a quarter of a century behind, because he could not possibly keep pace with the progress of a nation favoured by nature and fostered by education. The City and Guilds Institute has already done an incalculable amount of good in raising the standard of British excellence. May it long continue to spread its influence throughout the whole empire, and thus help materially in maintaining that supremacy which centuries of industry have evolved; and with these sentiments I propose continued and ever-increasing success to the City and Guilds of London Institute.

Mr. H. SAUNDERS, Q.C., replied on behalf of the City and Guilds, and, at considerable length, indicated the hopes and fears of the council. He pointed out that in the olden days the various guilds were really popular educators, and that their action in regard to the institute has been but a continuation of this policy.

At this juncture the result of the elections was announced, by which it was made known that the officers for the forthcoming year are as follows:

President—Mr. W. B. ESSON.
Vice-Presidents—Messrs. A. RECKENZAUN and A. T. SNELL.
Secretary—Mr. REGINALD J. JONES.
Treasurer—Mr. DUNCAN PEARCE.
Council—Messrs. LAMB, BONNE, RANCE, HAES, JONES, WASTE, DE GRAVE, HOLLAND.

Mr. A. T. SNELL then proposed the toast of "The Professors," acknowledging his indebtedness to their labours. He pointed out that the peculiar feature of the City and Guilds' instruction was to impart not only theoretical, but as much practical knowledge as possible. That the work was admirably done was indicated by the results, in that many of the old students were occupying very responsible positions in the industries for which they had been trained.

Prof. SILVANUS THOMPSON replied, stating that he had great pleasure in again responding to this toast, inasmuch as it permitted him to give an account of his stewardship to the people to whom he thought such an account was primarily due. He spoke of the members who attended the Finsbury College crowding the rooms, and stated that the long wished-for opportunity of obtaining more space seemed about to be fulfilled.

Prof. PERRY proposed what he termed the toast of the evening, "The Old Students' Association." He believed the association was doing good work, in that it continued to a certain extent the work of the lecture-room. Excellent papers were read and discussed at the meetings, and their social evenings helped to bring them together that they might exchange ideas, and so assist one another in their everyday work.

The PRESIDENT-ELECT (Mr. W. B. Esson) responded.

The intervals between the speeches were enlivened by instrumental or vocal music, in which the following gentlemen took part: Jno. Barton, Gordon Heller, Howden Tingen, T. E. Gatehouse, and Chas. G. Lamb. Altogether a very enjoyable evening was spent, and we certainly re-echo the wish that was expressed by various speakers that the Old Students' Association should continue to prosper and ultimately enrol a very large proportion of the present students in its ranks.

LEAMINGTON.

At the last meeting of the Leamington Town Council the following discussion took place on electric lighting matters:

The Watch Committee reported that the illuminating power of the gas for the month had averaged 15·63 candles, and that during the last 14 days they had tested 80 electric lamps; 22 of these were selected as bad, and their average illuminating power was 10·2 candles. The remaining 58 were taken haphazard, and their average illuminating power was 14·5 candles. The voltage pressure of the current supplied had always been well maintained. At the hours of street lighting it was normally 113 volts, or three volts above the contract. The bad lamps were being replaced by others, and the company had been requested by the surveyor to replace all defective lamps forthwith.

Alderman Wackrill said now the apparatus was fixed the committee had been able to ascertain the extent of the badness of some of the electric lamps, and the very best of them did not appear to be up to the mark. He pointed out that the contract imposed upon the company the supply of lamps of 16 c.p., whereas the test proved that, taking the average, they were not near this standard. Some few were extra good and reached as high as 18 c.p., whilst others would fall far below 14·5. The fact was, all the lamps had become so bad that the Council had not got anything like the light they were paying for.

The **Mayor** asked the surveyor how he arrived at the conclusions contained in the figures of his report with regard to the electric light tests. If 113 volts produced a light of 14·5 c.p., when it was running at 100 volts the light must be less.

The **Surveyor** explained in detail how and upon what system he had arrived at the results obtained.

Councillor Crowther Davies: Is there any clause which compels the company to supply a light of 16 c.p.

The **Clerk**: Yes, clearly the light is to be 16 c.p.

Councillor Crowther Davies said he would confine his remarks entirely to the question of the electric light. He was glad that, fortified as they were by the report of the borough surveyor, the committee had at last been able to furnish the Council with something that was trustworthy. It was clear to the members of the Council that for a very long time past they had not been having the light for which they were paying, and the company had been putting into its pocket money received from the Corporation in respect of a consideration which to a great extent had not been forthcoming. The clerk should be asked to consider whether they were not entitled to a return by the company of a certain proportion of the amount which they had paid to them in respect to the light which they had not supplied. After referring to the impartial manner in which the tests had been taken by the borough surveyor, Councillor Crowther Davies said if they as business men, sitting there to administer the funds of the ratepayers, were going to submit to that sort of treatment at the hands of their contractors, then he said they were spending the ratepayers' money as they would not spend their own. He protested now and should protest again against one shilling being paid to the company until the clerk had considered whether they should not be compelled to return a portion of the money paid to them, and whether they were entitled to another shilling until they supplied the full candle-power they had contracted to supply.

Councillor Bright said he should support Councillor Davies's position. They knew now the position for the first time, and they knew, too, that the state of the light was not what the company guaranted to supply to the Corporation. They had complained to the company, and the clerk had written, and there was no remedy, but now they had been able to state positively the nature of the deficient light supplied. The company said they would put new lights on at once. He should have thought that any man of business, who was looking out for contracts in other towns, would have thought it wise to have made the examination which the Corporation officials had now made.

Councillor Crowther Davies moved the following resolution: "That the town clerk be requested to consider whether the Electric Light and Power Company cannot be required to recoup the Corporation in respect of the past payments to the company having been made on the basis of the supply of a 16-c.p. light, which has not been supplied, and that he be requested to consider, further, whether the Corporation will be liable in future upon a *quantum meruit* in case the future light is not up to the contract standard."

Councillor Bright seconded, and it was carried unanimously.

SUGGESTIONS TOWARDS A DETERMINATION OF THE OHM.*

By Prof. J. V. JONES, Principal and Professor of Physics in the University College of South Wales and Monmouthshire, Cardiff.

"On the whole I am of opinion that if it is desirable at the present time to construct apparatus on the most favourable scale so as to reach the highest attainable accuracy, the modification of Lorenz's method, last described, is the one that offers the best prospect of success. Before this is done, however, it appears to me important that the value now three times obtained in the Cavendish Laboratory, by distinct methods, should be approximately verified, or disproved, by other physicists. To distinguish between this value and those obtained, for instance, by Kohlrausch, by Lorenz, or by the first B.A. Committee, should not require the construction of unusually costly apparatus. Until the larger question is disposed of, it seems premature to discuss the details of arrangements from which the highest degree of precision is to be expected."

The above passage, which concludes a paper communicated by Lord Rayleigh to the *Philosophical Magazine*, in November, 1882, nearly two years before the Electrical Congress at Paris, at which the legal ohm was defined to be the resistance of a column of mercury of 1 square mm. section and 1,060 mm. long, seems not to have met with adequate response in this country. So far as published experiments in English laboratories are concerned, the determination of the ohm remains where Lord Rayleigh left it, except for the contribution made by Glazebrook and Fitzpatrick in their measurement of the specific resistance of mercury in terms of the B.A. unit, which is one of the elements in the determination of the specific resistance of mercury in absolute measure by Lord Rayleigh's adaptation of Lorenz's method.

But though in England the scientific world has during the last seven or eight years occupied itself with other things, in other countries, and more especially in America and France, measurements have been made which have confirmed the Cavendish Laboratory result as against the other values mentioned by Lord Rayleigh in the passage quoted. Further, indication has already been given of the intention to employ as the unit of electrical resistance in the new Government Standardising Laboratory not the so-called legal ohm but the true ohm as nearly as it can be determined, and Major Cardew in the paper recently read by him before the Institution of Electrical Engineers has invoked the assistance of Lord Rayleigh and the British Association Electrical Standards Committee in the preparation of the required unit. The work judged necessary by Lord Rayleigh before the conditions of a more accurate determination could be advantageously discussed having been done, and practical necessity for an authoritative determination having arisen in connection with the standardising laboratory, the time seems ripe for a consideration of arrangements likely to secure high accuracy, and it is with this view that I venture to bring before the section the suggestions embodied in this paper.

In the hope of paving the way for a more accurate determination (and initially moved to the work by the invitation given in the passage which I first read) I have for a considerable time been engaged in submitting to the test of experiment certain modifications of the method of Lorenz which occurred to me as likely to lead to increased accuracy and certainty. I do not propose to trouble the section with the details of these experiments, which I hope may be published elsewhere. I mention them merely to give the suggestions brought forward the support derived from a determination actually made on the lines indicated. The experiments have been made in the laboratory of the University College at Cardiff with apparatus for the most part constructed in the college workshop. Five complete sets of observations were taken in the spring of this year with the following results for the specific resistance of mercury at 0deg. C. :

(i.)	94,103 absolute units.
(ii.)	94,074 „ „
(iii.)	94,093 „ „
(iv.)	94,045 „ „
(v.)	94,021 „ „

Mean 94,067 ± 10 (probable error). The result may be otherwise expressed by saying that the ohm is equal to the resistance of a column of mercury of one square mm. sectional area, and 106·307 centimetres long, the probable error being ± 0·012.

It is far from my intention to bring these numbers forward as the best determination possible by the method I have used. I do not think they at all represent the accuracy attainable if the apparatus were to be constructed on a scale a little larger, and with a certain perfecting of detail. Under such circumstances I am of opinion that a single set of observations will give a result accurate to one part in ten thousand, and that as a mean of a number of observations we may, perhaps, aim at the hundred-thousandth if regard is paid to the maintenance of definite temperatures in all parts of the apparatus, and if we can be said to know our length standards to this degree of accuracy.

In Lorenz's method a metallic disc is made to rotate in the mean plane of a coaxal standard coil. Wires touching the centre and circumference of the disc are led to the ends of the resistance to be measured, and the same current is passed through this resistance and the standard coil. The connections being rightly made we may, by varying either the rate of rotation of the disc or the resistance to be measured, so arrange matters as to have no change of current in the circuit of the disc and wires joining it to the ends of the resistance when the direction of the current through the resistance and the standard coil is changed. When this arrangement is effected there is a balance between the E.M.F. due to the motion of the disc in the magnetic field of the current in the standard coil, and the difference of potential at the ends of the resistance due to the current traversing it. If this adjustment is made, let us say that the apparatus is in an equilibrium position.

If M = the coefficient of mutual induction of the standard coil and the circumference of the disc ;
n = the rate of rotation of the disc (number of revolutions per second) ;
R = the resistance ;
γ = the current through the standard coil and resistance ; then in an equilibrium position,

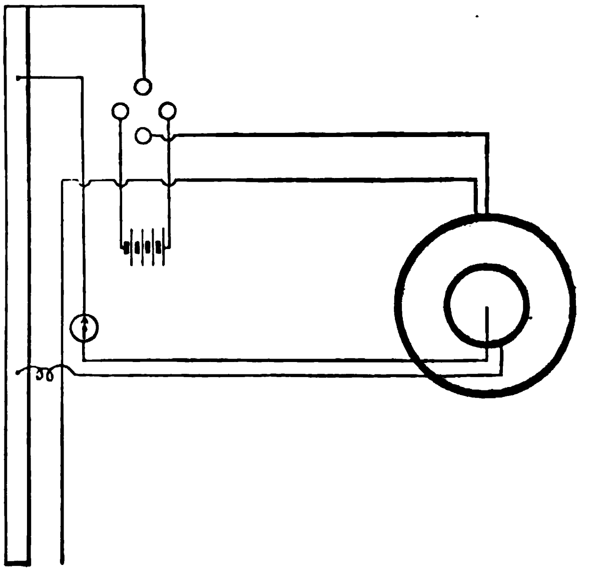
$$M n \gamma = R \gamma,$$

or,

$$M n = R.$$

In practice it is not possible to take the coefficient of mutual induction and the rate of rotation large enough to make the measured resistance more than a small fraction of an ohm*, and this has usually been regarded as one of the difficulties of Lorenz's method.

In order that the absolute unit may be recoverable at pleasure without the fatigues of a new absolute determination, it must be defined in practice by reference to the specific resistance of some standard substance, and for many reasons there is a consensus of opinion in making this standard substance mercury. The determination of the ohm as a practical problem, therefore, becomes identical with the determination of the specific resistance of mercury in absolute measure, and the small resistance measured by the method of Lorenz's must, in order to complete the investigation, be brought into relation and compared with the specific resistance of mercury. Lorenz himself evaded the difficulty by taking for his measured resistance the resistance of a mercury column contained in a glass tube ; the resistance of the column was then obtained in absolute measure, and the specific resistance calculated from the dimensions of the column. It is hardly possible, however, that the latter calculation can have been, or is likely to be, achieved with accuracy, however accurately the tube be calibrated. For, on the one hand, if the wires from the disc (the terminal portions of which may be called the electrodes) are led to the ends of the tube, the equipotential surfaces touched by them are not plane ; and, on the other, if they are let into the tube at some distance from the ends, it is difficult to see how the distance between them is to be measured with the requisite accuracy.



Under these circumstances Lord Rayleigh preferred to use solid conductors, overcoming the difficulty of comparing the resistance measured with ordinary standards by a shunt method, which made it possible to express it at once in terms of the B.A. unit. The B.A. unit being thus found in absolute measure, a separate investigation of the specific resistance of mercury in terms of the B.A. unit completed the determination. Rowland and others have adopted the shunt method of Lord Rayleigh, which may be said to be an essential feature in the more probable determinations by Lorenz's method. Spite of the conspicuous success which has attended the use of solid conductors by the shunt method I venture to suggest a reversion to Lorenz's use of mercury. The physical constant to be measured is the specific resistance of mercury, and if this can, by direct measurement, be determined with accuracy, it seems inconvenient and undesirable first to determine the resistance of the B.A. unit in absolute measure, and then to determine the specific resistance of mercury in B.A. units. If consistently with accuracy the artificial B.A. unit can be dropped out of our experiments as well as out of the result, and the measurements made directly on mercury, the simplicity would seem to be

* Paper read before the British Association.

* Lorenz	·0008	....	·002
Rayleigh	·002	....	·004.

a recommendation, and the argument is perhaps enforced by the consideration that there is very nearly as much divergence in the results of different observers for the specific resistance of mercury in B.A. units as there is in the values obtained for the B.A. unit in absolute measure.

The objections to the use of mercury in a tube are unanswerable; but the difficulties disappear if instead of placing the mercury in a tube it is placed in a long trough, and if instead of measuring the distance between the two electrodes, one electrode is kept fixed while measurement is made of the distance moved through by the other between two equilibrium positions corresponding to two different rates of rotation of the disc. The latter measurement it is easy to make with accuracy, for the movable electrode may be rigidly attached to the movable headstock of a Whitworth measuring machine or some other measuring bank placed parallel to the length of the trough; and the two equilibrium positions may be taken near the middle of the trough so as to avoid danger of curvature in the equipotential surfaces passing through the electrode in its two positions.

Let n_1, n_2, be the rates of rotation of the disc, and let l be the distance between the corresponding equilibrium positions of the movable electrode.

Then,
$$M(n_1 - n_2) = \frac{l}{A}\rho,$$

where ρ = the specific resistance of mercury.
A = area of section of the mercury column.

But we are met by a new difficulty, the determination of the section of the mercury column. The capillary depression at the sides of the trough would make it a most serious task to determine the section by direct measurement to the required degree of accuracy.

Fortunately, this difficulty may be overcome by a further differential method—viz., by making observations with the mercury at two different heights in the trough.

Let b = the breadth of the trough;
$h_2 - h_1$ = the difference of height of the mercury surface in the two cases;
and let A = the section of the mercury column when the mercury is at the lower position.

Then we have, denoting by dashed letters, the new values of the rates of rotation and the distance between the corresponding equilibrium positions—

$$M(n_1 - n_2) = \frac{l}{A}\rho$$

and
$$M(n'_1 - n'_2) = \frac{l'}{A + b(h_2 - h_1)}\rho$$

whence eliminating A

$$\rho = \frac{M\,b\,(h_2 - h_1)}{\dfrac{l'}{n'_1 - n'_2} - \dfrac{l}{n_1 - n_2}}$$

It is assumed in the above formula that the sides of the trough in that part of it traversed by the movable electrode are plane, parallel, and vertical.

Hence the determination of the specific resistance involves the determination of—

(i.) Four equilibrium positions, two at each depth, with the rates of rotation of the disc to which they correspond.

(ii.) The breadth of the trough in that part of it traversed by the movable electrode.

(iii.) The difference of level of the mercury surface at the two depths.

(iv.) The coefficient of mutual induction of the coil and disc.

The difficulties attached to the determination of equilibrium positions and the coefficient of mutual induction belong to all forms of Lorenz's method, whether the resistance measured is that of a solid conductor or that of a mercury column. Those specially incident to the use of a mercury column are:

(i.) The manufacture of an accurate trough, and

(ii.) The accurate measurement of the difference of level of the mercury surface in its two positions.

The trough used by me in the experiments of which I have spoken, was cut in paraffin wax contained in a strong casting of iron with its sides strengthened by outside ribs. The channel is approximately 43·5in. long, by 1·5in. broad, by 3in. deep. It was first cut by a cutter rotating about 2,000 times a minute, attached to the slide rest of the College Whitworth lathe, and subsequently finished by a scraper, attached in similar fashion, which took a very thin cut off sides and bottom. The result of the scraping was a very smooth and highly-finished surface.

This method of obtaining a channel for the mercury was adopted in the hope that so cut in the lathe it might present a breadth constant to two or three ten-thousandths of an inch. This hope was not realised; the results of subsequently calibrating the trough over the 10in. of it traversed by the movable electrode indicated a variation of as much as ·001in. in its breadth. The objections to the use of paraffin wax are:

(i.) Its softness makes it necessary to proceed with great care in measuring its breadth, lest damage should be done to the surface. This difficulty is satisfactorily surmounted in the form of internal callipers adopted in the calibration, which I must not stay to describe.

(ii.) The coefficient of expansion of paraffin wax is very large, its linear coefficient of expansion being about ·0003. A change of temperature would, therefore, cause distortion in the wax channel seeing that the wax is enclosed in an iron casing.

We endeavoured to meet the danger of inaccuracy due to this cause by measuring the breadth of the trough as nearly as possible at the same temperature as that at which the electrical observations were made, care being taken to maintain the trough at a uniform temperature throughout the observations. During the month of the observations, the temperature inside the box in which the trough was placed did not vary more than half a degree. But, notwithstanding this care, I am of opinion that the difference in the result of different sets of observations depends in the main upon variations in the trough due to varying temperature. But it is impossible to apply a correction, for paraffin wax is so bad a conductor of heat that its temperature could not be assumed to be that of the thermometers in the mercury channel; its temperature at any part would really be a function of ancient history.

Under these circumstances, I have come to the conclusion that I made a mistake in my choice of a substance; the disadvantages outweigh the apparent ease of construction. Probably a much more satisfactory result would be obtained by building up the trough of worked glass or scraped marble. I do not doubt that a sufficiently accurate trough might be made in either of these substances without straining the resources of the English mechanical engineer. We may observe that small errors become of less importance as the breadth of the trough is increased; and nothing but practical convenience limits the size of the trough we may employ, provided it is long enough in proportion to its breadth to make the equipotential surfaces plane over the part of it traversed by the movable electrode. It is further to be noticed that it is only the latter part of it that needs to be finished with the highest accuracy, and when the mechanical engineer has done his best, it is still possible to obtain a further approximation by a process of calibration.

The position of the mercury surface in the trough may be determined electrically by means of a pointed steel spherometer screw. The screw may be moved downwards until an electric circuit comprising the screw and the mercury is completed. It is of the utmost importance that the point of the screw should be kept clean, and that the mercury surface should be free from an oxide film, otherwise successive observations may differ from one another as much as ·001in.; but with clean mercury, if the point is carefully wiped with filter paper before making the observations, half a dozen observations may be without difficulty obtained, none of which differ from the mean by more than ·00004in. To preserve the point, sparking at the mercury surface should be reduced as much as possible.

In order that the capillary surface should be of the same shape at both levels, the surface should always be brought to its measured position by pouring mercury into the trough, and never by taking mercury out of it.

I am of opinion that both the measurements to which I have referred as peculiar to the direct use of mercury by the differential method—viz., that of the breadth of the trough and that of the difference of level of the mercury surface—may be made with an accuracy which will compare favourably with that which we can hope for in the determination of the equilibrium position, and, perhaps, also with that which we may expect in the measurement of the coefficient of mutual induction—measurements which are common to all forms of Lorenz's method.

Probably, also—though here I speak with hesitation and without experience—the accuracy will be as great as, if not greater than, that which attends the calibration of a glass tube, necessary to the determination of the specific resistance of mercury in B.A. units.

The electrical observations in Lorenz's method consist fundamentally in the determination of equilibrium positions, together with the rates of rotation to which they correspond. The equilibrium position is obtained when if the direction of the current is reversed through the standard coil and trough, the reading of a galvanometer inserted in the disc circuit is unaffected. In the experiments I have made I have found it best—following Lord Rayleigh—to take two sets of galvanometer readings for each equilibrium position, one set giving the change of galvanometer reading corresponding to reversal of the battery current for a position of the electrode slightly to one side of the equilibrium position; the other, the change of galvanometer reading, corresponding to reversal for a second position slightly on the other side of the equilibrium position. The galvanometer reading corresponding to the two positions of the commutator being called E and W, passage through an equilibrum position is indicated by a change in the algebraic sign of W - E. When W - E has been found for two positions slightly differing from one another, and including between them the equilibrium position, the latter may be found by simple interpolation. Since the readings, E and W, are not quite fixed, owing to small changes in the speed of the disc and variations at the brush contacts, it is necessary to take a number of reversals and to find W - E as the mean of the values obtained by combining the first value of E with the first of W, the first of W with the second of E, the second of E with the second of W, etc. The more quickly the reversals can be made to succeed one another, the better will be the results, for with rapid reversal variations in the position of the needle corresponding to no current through the standard coil (*i.e.*, variations due to change at the brush contacts), are less likely to supervene. It is, therefore, best not to wait for the needle to come even approximately to rest after the disturbance due to the induction current on reversal, but to take the readings for the extreme positions in an oscillation, and having previously found the coefficient of damping, to calculate the position of rest from these two readings.

The whole difficulty in determining an equilibrium position arises from the want of constancy in the readings E and W; and this want of constancy is due to two causes:

1. Variations in the E.M.F. at the brush contacts.
2. Variations in the rate of rotation of the disc.

It was with a feeling akin to despair that I watched the dance of the galvanometer needle during the first running of my apparatus, when the brush at the circumference of the disc was composed of a number of layers of thin phosphor bronze sheet controlled by a spring, and the dance continued, however well the circumference of the disc and brush were amalgamated at starting. Trials were made in the hope of improvement with amalgamated copper and amalgamated lead, and with the substitution of a dead-weight pressure for the spring. But no satisfactory result could be obtained. It was noticed, however, that after amalgamation the readings were fairly steady for a short interval, and it occurred to me that if mercury could be continuously supplied to the surface of contact between the brush and the disc, this steadiness might be maintained. This led on to the idea of a brush consisting of a single wire perforated by a channel through which a constant flow of mercury might be maintained from a cistern of adjustable height; and a brush of this description was finally adopted. It presents very great advantages over any other form of brush tried.

Prof. Rowland used three brushes on the circumference instead of one, and I do not doubt that a multiplication of brushes is advantageous. Three or more such brushes as I have described, resting by dead-weight pressure on the circumference of a disc ground true in place, would, I believe, give an excellent result. The grinding of the disc in place is an important aid to steadiness of galvanometer reading.

It is to be noticed that the value of W – E for a position at a given distance from the equilibrium position is proportional to the current through the standard coil. Hence the small variations due to the brush contacts which do not at all depend on the current through the coil become proportionately of less importance as the current is increased. We ought, therefore, from this point of view, to use as large a current as possible. But the magnitude of the current is limited by the fact that it has to traverse the wire of the standard coil, which must not be made so hot as to risk the destruction of its insulation. This consideration points to the use of wire of considerable diameter in the standard coil.

If the wire of the coil is made of large diameter, attention must be paid to the influence on the coefficient of mutual induction of the non-coincidence of the current with the axis of the wire.

The second cause of want of steadiness in the galvanometer needle is variation in the rate of rotation of the disc, and this is the real crux. We are not helped in determining the equilibrium position either by increasing the sensitiveness of the galvanometer or the magnitude of the current through the coil unless we procure a corresponding increase of steadiness in the running of the disc. We may increase the value of W – E for a position at a given distance from an equilibrium position in either of these ways, but unless there is a corresponding improvement in the constancy of the disc rotation no advantage results, for the variations in W and E resulting from changes of speed are proportional to W – E. Hence in the construction of apparatus for a new determination mechanical engineers should be invited to do their very best to procure a constant rotation. No time or trouble spent in securing this will be lost for the purpose in view.

In my experiments the disc was turned by an electromotor directly coupled to it, and driven from a battery of secondary cells. Each bearing was fitted with sight-feed lubricators, and a heavy steel flywheel was attached to the motor. The current passed to the motor through resistance coils, and could be varied continuously through a small range by a slide resistance of platinoid wire, after the larger adjustment had been made to obtain a speed, approximately that which was required. A shunt worked by a lever also provided the means of taking out or putting in a small resistance suddenly, so as to allow the observer taking note of the speed to counteract small variations due to alteration in the lubrication of the bearings.

To obtain improved steadiness, the chief point needing attention is lubrication. Some forced system of lubrication may be employed. Either oil may be pumped through the bearings, or they may be fed from a cistern placed at some height above them. Attention might also be directed to the friction of the brushes on the motor commutator. I do not think we can look hopefully to an increase of steadiness from the employment of any hand-brake controlled by the observer, for the mischief is done, and the alteration has come about before he observes that it is his duty to put the brake on or off. In fact, the galvanometer needle picks up the alterations much sooner than the observer's eye. An electromagnetic brake might be useful for adjusting the speed, but could not give any additional steadiness to the galvanometer needle. This can, I think, only be procured by perfection of mechanical workmanship, and increased attention to the truth of rubbing surfaces, and their proper lubrication.

It remains to speak of the measurements necessary to enable the calculation of the coefficient of mutual induction to be performed. To facilitate an accurate determination of the mean radius of the standard coil, I desire to suggest that it should be a coil consisting of one layer of wire. The advantage in constructing a standard coil with a single layer of wire is that every part of it is visible, and that nothing is done to alter the position of the wire after measurements are made. If a coil consists of many layers, it is not quite easy to say where, after measurement, the lower layers go to under the pressure of the superincumbent layers. Lord Rayleigh found, in the case of certain coils used by him, that the mean radius calculated from measurements made in winding was greater by one part in 2,000 than the mean radius calculated from measurements made in unwinding, a result clearly due to the compression of the lower layers by the layers above them.

We should, therefore, expect that if the mean radius of a coil of many layers is calculated from measurements made in winding, it will be reckoned too large. In the face of this, it is interesting to note that in the measurements made by Lord Rayleigh by the method of Lorenz, the series in which the coils are so placed as to make the induction coefficient nearly independent of the mean radius, gives a result rather larger than the other series, which is what might be expected if the mean radius is over-estimated. But the smallness of the variation (a little over one part in 10,000) seems to show that the error of mean radius must be very small for the pair of coils used by Lord Rayleigh. In general, we should expect, as far as this cause goes, that values of the specific resistance in determining which coils of many layers are used would come out too low, since an overestimate of the mean radius of the coil means an underestimate of the coefficient of mutual induction. The apparent disadvantage of a coil of a single layer is that the number of turns will be fewer, and, therefore, the coefficient of mutual induction of the coil and disc smaller than in the case of a coil of many layers. We may, however, in order to get a sufficient number of turns, make the coil of greater axial length than has been customary. But we cannot, in that case, use Lord Rayleigh's formula of approximation in calculating the coefficient of mutual induction. Under these circumstances, a new formula, applicable to a coil of moderate axial length, was a desideratum. Such a formula I obtained by the direct integration of the expression

$\int\int \frac{ds\, ds'}{r} \cos \epsilon$ for a circle and coaxal helix.

It is of the form

$$M = -8n\pi \frac{A-a}{A+a} \Sigma (-1)^m \frac{1.3.5..2m-1}{2.4.6...2m} \cdot \frac{1}{2m+1} \left(\frac{x}{A+a}\right)^{2m} P_m.$$

Where A = the radius of a circular section of the cylinder determined by the helix.
a = the radius of the circle.
n = the number of the turns of the helix.
$2x$ = the axial length of the helix.*

and
$$P_m = \int_0^{\frac{\pi}{2}} \frac{\cos 2\theta\, d\theta}{(1 - c^2 \sin^2 \theta)} \; \frac{2m+1}{2}$$

when
$$c = \frac{2\sqrt{Aa}}{A+a}$$

P_m may be expressed in terms of c, F (c), and E (c).

This is the formula I have used in calculating the coefficient of mutual induction of the coil and disc in the experiments already mentioned. The coil is of double silk-covered copper wire of about ·02in. diameter, resting in a screw thread of ·025in. pith, cut on a hollow cylinder of brass of about 21in. external diameter. The axial length of the cylinder is something over 4·5in., and 185 turns of wire are wound on it. The disc has a radius of about 6·5in., and the coefficient of mutual induction is about 17,000in. This is a little more than a tenth of the coefficient of mutual induction of the coils and disc used by Lord Rayleigh in the first and second series of his experiments by the method of Lorenz, but it was found to be ample for the purpose in hand.

The mean radius of the coil was measured in the Whitworth measuring machine.

Uncertainty arose from two causes:

(i.) The silk covering of the wire;
(ii.) The ellipticity of the coil cylinder.

The silk covering of the wire is of slightly varying thickness, and suffers compression to a varying extent during a series of measurements.

A standard coil, consisting of naked wire wound in a screw thread cut on a cylinder of insulating material, would be preferable to one of covered wire wound on a metal cylinder. There is, however, difficulty in finding a suitable insulating material. Wood immediately occurs to one's mind, but a large coil of wood, even though it be built up of many pieces, is apt to change its shape with age and varying atmospheric conditions. But if a suitable insulating material, that can be turned true, and that will retain its shape, can be found, a single layer of naked wire in a screw thread cut on a cylinder of this material, would give us a coil the mean radius of which might be easily measured with certainty in the Whitworth machine to far more than one part in 10,000.

The ellipticity of the coil cylinder deserves notice. The cylinder was turned with great care in the lathe already mentioned. It was cast with three lugs by which to bolt it to the face plate, and subsequently in precisely similar fashion to the strong brass frame which serves as its support during use. The first operation was roughly to fit the lugs to the face plate by filing. A roughing cut was then taken over the entire surface of the cylinder so as to get rid of as much as possible of the internal strain due to unequal cooling of the casting. It was next unbolted and the lugs were carefully scraped to fit the face plate, and after again bolting it to the face plate the final turning was proceeded with. Very fine cuts were taken in finishing, and it was hoped that by these precautions we should secure a true right circular cylinder. Nevertheless, measurements made in the Whitworth measuring

* *Phil. Mag.*, January, 1889. Read before Physical Society November 10th, 1888.

PROVISIONAL PATENTS, 1890.

OCTOBER 13.

16264. **Improvements in electromotors and dynamo machines.** Henry Chitty, 13, Brackley-terrace, London.

16272. **Improvements in or appertaining to globe or shade holders for incandescent electric lamps, in part applicable to other lamps.** Richard Llewelyn Benson Rathbone, 6, Lord-street, Liverpool.

16278. **Improvements in electrical conductors.** Frederick Walton and Henry Edmunds, 28, Southampton-buildings, London.

16279. **Improvements in the process and apparatus for electrical casting of metals.** Nicholas Slawianoff, 28, Southampton-buildings, London.

16280. **Improved means of preventing defects, such as blow holes and the like, in castings by electricity.** Nicholas Slawianoff, 28, Southampton-buildings, London.

OCTOBER 14.

16322. **Improvements in insulating cells for electric batteries.** Stanley Charles Cuthbert Currie, 323, High Holborn, London. (Complete specification.)

16324. **Improvements in the method of and apparatus for casting frames or supports for battery plates or elements.** Henry Herbert Lloyd, 323, High Holborn, London. (Complete specification.)

16346. **The regulation and control of storage battery systems.** Stanley Charles Cuthbert Currie, 24, Southampton-buildings, London. (Complete specification.)

16347. **Improvements in electric clutches.** Peter William Willans, 24, Southampton-buildings, London.

16351. **Improved mechanism for elevating and directing machine guns and electric light projectors from a distance.** Edmond Meyer Tudor Boddam, 28, Southampton-buildings, London.

OCTOBER 15.

16377. **Improvements in electrical cut-outs.** Archer Turner and Arthur Everard Levin, 27, Martin's-lane, Cannon-street, London.

16380. **Improvements in electrical apparatus for regulating the speed of engines, starting and stopping shafts, hoists, and other machines.** James Tate, Sunbridge-chambers, Bradford.

16399. **Improvements in or relating to the electro-deposition of metals.** Alfred Julius Boult, 323, High Holborn, London. (Louis Albert Joseph Joray, France.)

16415. **Improvements in methods of and apparatus for utilising electricity in the formation of sheet metal articles.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

16416. **Improvements in methods of utilising electricity in the formation of metallic cartridge cases and other articles.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

16424. **Improvements in and relating to phonographs.** Roland Frederick Willett and William Walter Robinson, 191, Fleet-street, London.

OCTOBER 16.

16467. **Improvements in the manufacture of metallic sheets, strips, or wires by electrolysis, and apparatus for that purpose.** Francis Edward Elmore, 28, Southampton-buildings, London.

16472. **A new or improved automatic coin-freed apparatus for giving electric shocks.** Benjamin John Stacey, 76, Chancery-lane, London. (Complete specification.)

OCTOBER 17.

16518. **Improvements in arc electric lamps.** James Eglinton Anderson Gwynne, 11, Furnival-street, London. (Complete specification.)

16522. **Improvements in the methods of and apparatus for working metals by electricity.** George Dexter Burton, 52, Chancery-lane, London. (Complete specification.)

16534. **New or improved electrical priming or electrical frictional priming screw plugs.** Alfred Longsdon, 33, Chancery-lane, London. (Fried Krupp, Germany.) (Complete specification.)

OCTOBER 18.

16556. **Improvements in devices for holding the receivers of telephone instruments or the like.** William Phillips Thompson, 6, Lord-street, Liverpool. (Jehial Tuttle Moore, United States.)

16570. **Improvements in electric motors.** Henry Groswith, 62, St. Vincent-street, Glasgow. (Complete specification.)

16571. **Improvements in secondary batteries.** Charles W. Kennedy and Henry Groswith, 62, St. Vincent-street, Glasgow. (Complete specification.)

16603. **Improvements in secondary batteries.** Charles James Hall, 433, Strand, London.

16607. **Improvements in or connected with electric switches.** Christen Rees Bonne, 41, Eastcheap, London. (Wilhelm Paul Domiels, Germany.)

SPECIFICATIONS PUBLISHED.

1888.

12264. **Preparing metallic surfaces for non-adhesive electric deposits.** F. E. and S. Elmore. 6d.

1889.

11941. **Switchboards for telephone exchange.** Mix and Genest, Limited, and another. 8d.

18261. **Joints for telegraphic, etc., wires.** Hooper-Rastrick. 6d.

18821. **Electric baths.** Gaertner. 8d.

18939. **Railway, etc., vehicles propelled by electricity.** Holt. 8d.

1890.

8392. **Conduits for electric cables.** Thompson (Jacob Fréres et Cie.). 6d.

11466. **Electromagnetic friction clutches.** Foote. 11d.

11863. **Electric switches.** Strode and Gill. 6d.

12171. **Electric motor mechanism.** Mower. 8d.

12231. **Commutators for electrical machines.** Vail. 6d.

12634. **Dynamo-electric machines.** Foote. 8d.

13013. **Electrodes for primary, etc., batteries.** Pepper. 4d.

13344. **Galvanic batteries.** Allison (Hathaway). 8d.

13485. **Electrical glow lamp conductors.** White. 6d.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the week ended October 17 amounted to £4,891.

Meeting.—The third ordinary general meeting of the Westminster Electric Supply Company will be held on Wednesday, the 5th November, at the offices, 4, Victoria-mansions, S.W., at 12 noon.

Western and Brazilian Telegraph Company, Limited.—The receipts for the week ended October 17, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,842.

New Address.—Messrs. Paterson and Cooper, electrical engineers, of Pownall-road, Dalston, have opened a West-end showroom at 3, Prince's-mansions, Victoria-street, Westminster, where samples of their manufactures may be seen by intending purchasers.

Electro-chemical Syndicate, Limited.—This Company has been registered by Lovell and Trimnel, Monument-buildings, E.C., with a capital of £5,000 in £1 shares. Object: to acquire and turn to account inventions, patents, etc. Registered without articles of association.

Consolidated Telephone Construction and Maintenance Company, Limited.—This Company have declared an interim dividend for the half-year at the rate of £6 per cent. per annum on the preference shares and £5 per cent. per annum on the ordinary shares, both less income tax, payable on November 14.

West India and Panama Telegraph Company, Limited.—The Board of this Company recommend a payment of 6s. per share to June 30 last on the first preference shares, and £3 per share on account of arrears on the second preference shares. The sum of £1,500 is to be placed to reserve, leaving a balance of £322.—The estimated receipts for the half-month ended Oct. 15 were £2,887, against £2,064. The June receipts, estimated at £6,385, realised £6,428.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2½
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	8

NOTES.

Bath.—The first quarter's bill for lighting this town has been paid, total £524.

Paris.—The sewers are being widened here to permit of more telephone wires being laid therein.

Norwich.—The Town Council have consented to the Norwich Electric Company applying for a provisional order.

Kidderminster.—The Town Council will apply for an order. Several of the councillors are directors of the gas company.

Berlin.—All theatres and places of amusement accommodating more than 800 persons are to be lighted by electricity in 1892.

City and South London Railway.—We learn that this underground electric railway will be opened by the Prince of Wales next Tuesday.

Leeds.—A new post office is to be erected here, and not before it was wanted, on the site of the old Coloured Cloth Hall. It is to have electric lights.

Hotel Lighting.—A scheme is on foot to erect a large hotel at Southend, the cost to be about £50,000. It should be lighted electrically to be a success.

Search Lights.—*Electricité* says that the first use made of a search light on board ship was in 1867 on Prince Napoleon's yacht, the "Reine Hortense."

Submarine Telephony.—The German Post Office have, it is said, recently succeeded in telephoning between Heligoland and Cuxhaven, using the telegraph cable.

Dewsbury.—The borough surveyor's plan showing the streets to be lighted electrically has been approved by the Town Council, who have determined to apply for an order.

Bacup.—At the last meeting of the Town Council the town clerk said he had received a number of letters *re* electric lighting, which he did not think it necessary to read.

New Cable.—The French Government have decided on laying a cable between Marseilles and Tunis and Marseilles and Oran. A cable between France and Denmark is also contemplated.

Royal School of Mines.—The Government institution now known as the Normal School of Science and Royal School of Mines is in future to be called the Royal College of Science, London.

City and Guilds Institute.—We notice that 256 candidates entered for the last technological examinations of the City and Guilds in electric lighting, while telegraphy only claimed 117 followers.

Dorking.—The Electric Light Committee of the Local Board (Mr. Clift, chairman) are, with the surveyor, to visit electrically lighted towns in search of hints for future guidance and possibly adoption.

Milling Machines.—Several specialities in milling machines are being introduced by Messrs. Cunliffe and Croom, of Manchester, among others milling and profiling machines for electrical work.—*Engineer.*

Locomotive Headlight.—Telegrams describing trials of the Huntingdon headlight on the New Jersey Central Railway, at Cummunipaw, were published last Saturday, but the electrical details were rather mixed.

Blackpool (Lancs.).—With reference to our note in last week's issue as to the proposed new pier at South Shore, Blackpool, we now learn that the engineers are Messrs. Magnall and Littlewood, of Manchester.

Coventry.—The City Council have decided to oppose "company enterprise," and to apply for an order, though somewhat reluctant to do so. An electric lighting committee has also been appointed to consider details.

Enterprise.—We congratulate our contemporary *The Street Railway Journal* on its enterprise in publishing a daily issue during the session of the convention of the American Street Railway Association held this month.

Heckmondwike (Yorks.).—The Local Board have determined, by the casting vote of the chairman, to apply for an order. The enquiries of the Special Committee as to electric lighting are said to have resulted very satisfactorily.

Spain.—No wonder the electric light is finding favour in Madrid (*vide* our last issue, page 352), for we read that gas is as high as 9s. per 1,000ft. It is stated that the two central stations just started have already found customers for 16,000 lights.

Electric Gyroscope.—M. Dumoulin Froment, son-in-law and successor of M. Froment, the well-known instrument maker, says that he, and not M. Trouvé, was the first to construct an electric gyroscope. M. Froment (the elder) exhibited an electrically driven gyroscope in 1867 in Paris.

International Mining Exhibition.—Among the awards to exhibitors at this exhibition, held at the Crystal Palace, we notice the names of Lars Bristol, London, portable electric safety lamps, for mining and other purposes; and John Davis and Son, Derby, Davis's self-timing anemometer.

Southend.—In reply to the East Coast Electric Light Company, who pointed out to the Local Board the advantages which would accrue from their (the company) making the application for an order, the Board said that they intended to stick to their decision to make the application themselves.

Dresden.—The Town Council have resolved to postpone the construction of a central station until the Frankfort Exhibition has been held, from which they hope to gain information. The three firms who tendered for the lighting (mentioned in our last issue) will then be invited to compete again.

Rothschild-Deprez Combination. — *L'Electricien* says that the Société Parisienne d'Eclairage et de Force par l'Electricité has been floated to replace the Rothschild-Deprez combination known as the Société de la Transmission de la Force par l'Electricité. The capital is fixed at 10,000,000f. in 20,000 shares.

O.S.A.—The president of the Old Students' Association, Mr. W. B. Esson, will deliver his inaugural address on Thursday next at Finsbury College at 8 a.m. His text will be "Industrialism," a word of recent mintage, we believe, but a suggestive one withal. We have no doubt Mr. Esson will do justice to his subject.

Vienna.—It is stated that the Emperor of Austria has decided to light the Imperial Palace at Vienna electrically. Eight thousand 16-c.p. incandescents will be required. The firm of Egger has the order for the installation, and the current will be taken from the mains of the International

Electric Company. The Royal chateau at Pesth is also to be lighted.

Large Engine and Dynamo.—The large Armington and Sims engine in factory K of the Thomson-Houston works at Lynn, Mass., was started a week or two ago. The engine is of 440 h.p., and runs at 240 revolutions per minute. It drives a 2,600-light alternating machine, which supplies the current for the test lamps.

Godalming.—The Corporation have renewed their contract with the gas company, on whom the threat of the introduction of the electric light had produced a marvellous effect, for one year. The Lighting Committee are in the meantime, however, by no means to lose sight of the electric light, as the Corporation would like to be in a position to adopt it in a year's time.

Franklin Institute.—The programme of this institute for 1890-91 includes papers by Dr. Louis Bell on "Electricity as a Rival to Steam"; Prof. Richards, of Lehig University, on "The Aluminium Problem"; Prof. Elihu Thomson on "Induction of Electric Currents and Induction Coils"; and by Mr. F. L. Garrison on "New Alloys in their Engineering Applications."

New Subway.—A new subway under the Mersey for vehicular traffic will soon be in hand. It will be about one mile long, with a width of roadway of 19ft. The steepest gradient, extending over 440 yards in the centre of the tunnel, will be 1 in 40. There will be three hydraulic lifts at each end, and the tunnel will be painted with white enamel and lighted electrically.

Cobalt and Nickel.—We understand that the process of Herr Wilhelm Schöneis for obtaining pure nickel and cobalt solutions from the relative ores and smelting products has been put to practical and successful use at Beierfeld, in the Erzgebirge, by the Hütte Silberhoffnung. *Kühlow* believes that the present very high price of oxide of cobalt will soon experience a reduction.

Gloucester.—The City Council will apply for an order, the following being a list of the streets to be lighted within two years after the commencement of such order: The Cross, Northgate-street, Southgate-street, Eastgate-street, Barton-street, from Eastgate-street to the railway crossing, Westgate-street, George-street, and Clarence-street, and the road leading therefrom to the railway station.

Battery Lighting.—The following does not at first sight (or second either) appear to be an economical way of lighting. At the concert room of the Royal Conservatoire at Brussels the orchestra is lighted electrically, the current being supplied from secondary batteries, which are charged by a primary battery placed outside in a courtyard. The latter is said to be the production of a M. Buffet.

Douglas (Isle of Man).—Yesterday week the foundation stone of the Eiffel tower to be erected at Douglas in connection with a suspension bridge, was laid by the Earl of Lathom. The height of the tower will be 375ft., and it will contain various floors devoted to concerts, skating rinks, refreshments, etc. On the top will be a little tunnel containing a large arc lamp. Mr. T. Floyd, C.E., of Westminster, is the engineer.

Budapest Tramways.—Delay has been caused in making the new electric tramway in Budapest by a decision of the Board of Works, that the line must be worked on the underground conduit system in the town, and on the overhead system in the suburbs. This decision has, however, been reversed by the Government, as it would prevent successful and continuous working. It is now expected that the whole of the electric tramways in this town will be worked overhead.

Dusseldorf Lighting.—Some time ago we noticed that Schuckert and Co. had the contract for a 20,000-light station at Dusseldorf. We now gather that auxiliary accumulator stations will be erected, and that continuous-current machines will be used. The central station will have three engines of 300 h.p., and the dynamos will furnish a maximum current of 840 amperes at 380 volts pressure. The accumulators at the two auxiliary stations will have a capacity of 13,280 ampere-hours, and a discharge of 3,980 amperes.

Mine Lighting.—A writer in the *Iron and Coal Trades' Review* makes the following comparison between the cost of electricity, gas, and oil for mine lighting. The estimates are for plant for a colliery raising 1,000 tons per day:

	Original outlay.		Working cost, including repairs and depreciation, per annum.
Electricity	£200	......	£60
Gas—main pipes and fittings	150	......	153 at 3s. 6d. per 1,000.
Oil	80	......	140

Birmingham Electric Trams.—The cause of some little irregularities in the service of the Bristol-road cars has been traced to the roadway (wood), which has been so laid that expansion and contraction due to weather is at a maximum; consequently the car wheels grind against the rails to such an extent as to materially retard their progress. This was apparently not allowed for at starting; but we understand that, pending a relaying of the road, such provision of extra power will be made as will overcome this cause of irregularity.

Owens College, Manchester.—A prize of £10 has been offered by Mr. William Mather, M.P., for the best essay on some subject connected with the technical applications of electricity; the competition being open to students working in the physical laboratory of the Owens College during the day or evening. The award is to be given at the end of the present session, and Dr. Edward Hopkinson has offered a similar prize to be awarded next session. The subject for the present session is "Recent Progress in the Science of Magnetism."

Lyons.—Some further details of the scheme for utilising the water power of the Rhone to generate electricity for distribution in and around Lyons have come to hand. The hydraulic station will be at Cusset, and will have 26 turbines of 500 h.p. (French) each; 24 of these will be in daily use and two in reserve. Each turbine will drive two 250-h.p. dynamos, and the current will be distributed by six underground mains, from which branches will lead off as required. We may, however, remind our readers that this scheme is as yet but an *avant-projet*, or as we should say, "on paper."

The First Atlantic Cable.—Mr. F. C. Webb, of 27, Forest-road, Dalston, N.E., has published a sheet of drawings giving longitudinal sections of H.M.S. "Agamemnon," and the U.S. frigate "Niagara," showing the position of the cable in the holds of the two vessels, together with the length (in knots) in each tank, distinguishing the different types. A line or two at the top of the drawing gives the names of the chiefs of the 1858 expedition. We have no doubt there are many cable men to whom these drawings will prove of historic interest. They can be obtained of Mr. Webb at the price of one shilling.

City Lighting.—At the meeting of the Commissioners of Sewers last week, a Mr. Stringfellow wrote saying that, in view of the proposed electric lighting for the western district of the City, he begged to state that a new kind of gas was about to be introduced to the public, which was as good as the electric light, and far cheaper. The letter was referred to the Streets Committee. We may point out to Mr. Stringfellow that "about to be" has too decided a smack of futurity about it. When the gas has been introduced, and tried and found to be not only cheaper but better than the electric light, it will stand a better chance of adoption.

Newcastle Infirmary.—Four electric lamps have been fitted up in the operating theatre of this institution. Two of them are placed over the operating table, and one is fixed at each end of the room. The installation has been arranged by Mr. Charleton, electrical engineer, of Singleton House-buildings, Northumberland-street, and that gentleman has not only generously made the institution a present of the lamps and appliances, but has carried out the work of fitting them up free of charge. The current is supplied free by the Newcastle Electric Lighting Company for the ensuing six months. The light is stated to have already given great satisfaction to the medical staff.

Southampton.—The Southampton Electric Light Company have begun the conduits for their mains along the footway, High-street. The conduit is formed of a concrete floor and sides, with stone slabs on top, and manholes at intervals. The following particulars as to the present position of the company may be interesting. The nominal capital is £30,000, divided into 4,000 preference and 2,000 ordinary shares of £5 each; 577 ordinary shares have been taken up, and there has been paid on these shares the sum of £1,071. The company has issued debentures to the amount of £2,100 for the purpose of satisfying liabilities under a contract between the company and Messrs. Crompton and Co., for the supply of plant and mains.

Ball Lightning.—M. Von Lepel produces ball lightning with an influence machine as follows: two thin copper wires connected to the poles of the machine are kept at a certain distance from the opposite sides of a plate of mica, ebonite, or glass, when little red luminous balls appear which move hither and thither, sometimes quickly, sometimes slowly, occasionally remaining still. The best effects are obtained with a plate of glass or paper disc painted with paraffin. M. Von Lepel is of opinion that small liquid or dust particles are the vehicles of the luminous phenomenon. A light breath of air will cause the balls to disappear with a slight crackle. These results can only be obtained with weak pressure, for when this is increased the ordinary spark discharge occurs.

Presentation.—On Friday, the 23rd inst., a deputation, consisting of about 20 of the National Telephone Company's employés in Scotland, comprising all the principal district managers and engineers, waited on Mr. A. R. Bennett and presented an illuminated address recapitulating his services to the company during the eight years of his administration as general manager of their affairs in Scotland, and expressing regret at his resignation and good wishes for the future. The address was accompanied by a costly set of Sir William Thomson's electrical testing apparatus, manufactured by the India Rubber, Gutta Percha, and Telegraph Works, of Silvertown. The presentation was acknowledged by Mr. Bennett in suitable terms, and he was afterwards entertained to luncheon.

Criterion and Gaiety Restaurants. — Improvements have been recently made at the Criterion, and additional lighting plant has been put down, about 1,000 lights having been added. The dynamos for feeding these were supplied by Messrs. Mather and Platt, and are of the Edison-Hopkinson type. The ventilating fans in the theatre and other parts of the building are now worked by Elwell-Parker motors, supplied by the Electric Construction Corporation. We hear they have given satisfaction. The Gaiety has been wired throughout, and about 300 Edison-Swan 16-c.p. incandescents and four Brockie-Pell 12-ampere arcs are supplied from the Metropolitan Company's mains. Mr. Hargreaves, engineer to Messrs. Spiers and Pond, has had charge of the above work. The light has proved very satisfactory so far, the arcs being remarkably good.

The Electrical Engineering Corporation.—We have received a copy of the catalogue issued by this company, which includes very complete information as to the specialities in the way of dynamos, lighting apparatus, launch driving, and electric traction manufactured by them. These have frequently been referred to in our pages. There are numerous illustrations and the type is clear and distinct. We have pleasure in bringing it to the notice of our readers, who may be reminded that the company's London offices are at 3, Princes-mansions, S.W. This corporation has for the last nine months been making considerable extensions at their works at West Drayton, and these are now complete. In the course of a week their new machinery will be put to work, and among the new machine tools there will be some of the largest employed in the electrical industry.

Electric Lighting in Australia.—At a recent meeting of the New Australian Electric Company in Melbourne, the chairman stated that the lighting business was steadily increasing. The company's new station near South Yarra was nearly completed, and would be ready for work in a month's time. The equipment of the station had been pronounced by English experts to be one of the most perfect yet constructed, being a duplicate of one of the latest and most approved stations erected in London. The capacity of that portion of the station nearly completed was equal to about 15,000 lamps; but the building had been so arranged that its extension could be carried on from time to time to meet all requirements. The mains are being rapidly laid throughout Richmond, Prahran, and South Yarra; Government House, the Observatory, and the Prahran Public Library being the first points to be served.

Tramcar Emergency Brake.—On page 443 of our last volume (*Electrical Engineer*, June 6) we gave some account of trials made at Grimsby with the emergency brake invented by Mr. Louis Porri, of that town. The tests, though of considerable severity, were satisfactorily undergone; and, as a result, the Board of Trade, to whom General Hutchinson, the inspector present at the trials, reported favourably, have decided that Mr. Porri's apparatus appears to fulfil the requirements of an emergency brake. As a result of the trials in question quite a crop of emergency brakes have sprung up, which have been favourably reported on to the Board of Trade. We may, however, point out that, to the best of our belief, Mr. Porri was the pioneer on the road to success in this direction, and is proportionately deserving of credit. We hope it will not be long before tramway companies, whatever motive power they employ, will adopt an emergency brake; for in towns

where steep gradients prevail runaway cars have been unpleasantly frequent of late.

Electric Lighting in Paris.—The lighting of the Gran Plaza de Toros, in Paris, has been carried out by the Cance Company and the Compagnie Nationale d'Electricité. The arena is lighted by a circle of 145 Cance lamps suspended from the cupola at a height of 44 metres. Two Powell steam engines, and one by Challigny, drive (by means of shafting and pulleys) three compound-wound Gramme machines, giving 550 amperes and 70 to 75 volts (at the terminals) at full load. Sliding bedplates are provided to take up slack, and these are insulated from the floor by wooden platforms. The three dynamos feed 145 Cance 8-ampere lamps, but this number may be increased eventually to 180. The cables between the dynamos and the switchboards are composed of 60 copper wires. The Cance lamps are fitted with clear glass globes, and have cinder catchers, which hang by light chains. The stables, etc., are lighted by the Compagnie Nationale, a Ferranti (2,400-volt) machine, giving 45 amperes, and used in conjunction with transformers, feeding some arc and incandescent lamps.

Sutton (Surrey).—At the last meeting of the Local Board, the committee appointed to consider Mr. Holford's motion relative to building baths, public offices, fire stations, etc., for the town on the site of Ruck's chalk pit, in the High-street, reported that they had received a petition from 44 of the principal tradesmen of Sutton that the town should be lighted by electricity, and they recommended that the Board should take immediate steps to secure the site of Ruck's chalk pit for the proposed scheme. Mr. Holford, in proposing the adoption of the report, said that as to the electric lighting, they could light the town with lamps giving nearly double the light at present for the sum of £1,600 per annum. The electric lighting scheme would reduce their rates materially. He moved a resolution to the effect that the Board approve of the scheme for municipal buildings, electric light, and baths, and that, as a preliminary step, the committee be empowered to make an offer for the freehold site in the High-street known as Ruck's chalk pit. After discussion, the matter was adjourned to be considered at a special meeting.

Electro-Harmonic Society.—The next smoking concert will be held on Friday next in the Banquet-room of the St. James's Hall Restaurant at eight o'clock. The following is the programme: Part I.—Trio, "Wine! The Magician" (Rose of Castile) (Balfe), Mr. Branscombe, Mr. Tufnail, and Mr. Grove; song, "Return with the May" (Van Lenep), Mr. Musgrove Tufnail; songs, (*a*) "To Chloe in sickness" (Sterndale Bennett), (*b*) "If thou art sleeping" (Gounod), Mr. Edward Branscombe; harp solo, "Le reveil des Sylphes" (Alvars), Mr. G. T. Miles; song, "The Wanderer" (Schubert), Mr. Ben Grove; pianoforte solo, Mr. Alfred Izard; recitation, Mr. C. Fry. Part II.—Duet, "Friendship" (Marzials), Mr. Branscombe and Mr. Tufnail; song, "Good Night, Beloved" (Balfe), Mr. Edward Branscombe; song, "The Monarch of the Storm" (Mullen), Mr. Musgrove Tufnail; harp solo, "The Bells of Aberdovey" (Thomas), Mr. G. T. Miles; song, "Love's Omnipresence" (T. E. Gladstone), Mr. Ben Grove; recitation, "The Village Choir" (Anon), Mr. C. Fry; trio, "The Wreath" (Mazzinghi), Mr. Branscombe, Mr. Tufnail, and Mr. Grove.

Lighthouse Illuminants.—The report of Sir Geo. Stokes, Lord Rayleigh, and Sir Wm. Thomson, who were appointed a committee to enquire into the results of the South Foreland Lighthouse experiments, and which is the final report dealing with the matter, has been published. One question was whether the Trinity House were right in ignoring gas as a result of the experiments, and this is what the committee say on the matter: "Though gas possesses undoubted advantages over oil in some respects, such as facility of increasing the power on the sudden occurrence of fog, absence of the necessity of trimming, power of making instantaneous transition from light to dark and conversely, we do not think these advantages sufficient to outweigh the advantages which mineral oil possesses for ordinary employment on account of its simplicity and economy. We think, too, that for specially important sea lights the experiments show that electricity offers the greatest advantages. At the same time we see no reason for confining the choice to these two alternatives, nor does it appear that the words of the report so confine it. There may be special reasons in particular cases for giving the preference to gas, and it seems even desirable that mariners should have the opportunity of witnessing the effects of different systems, which would thereby be subjected to the test of long-continued practical experience."

The Electric Light for Divers.—On Monday last Mr. Applegarth, of Mansion House-chambers, Queen Victoria-street, E.C., exhibited at the offices of *Electrical Plant*, Queen-street, E.C., some recent improvements in diving dresses which have been carried out by M. Denayrouze. In the new dress there are but three pieces—helmet, collarette, and body; and the helmet is fitted to the collarette by a screw-spring adjustment, thus doing away with all loose pieces in the shape of nuts. The dress has been adopted in the French navy. The helmet is also fitted with an incandescent lamp, inclined forward at an angle of about 30deg., and fitted with protector and mirror. On Monday the lamp was fed from an accumulator. If it is proposed, as we believe it is, to have the battery in a boat, and that the diver shall drag the leads about with him, we do not think the plan will work well, especially where the searching of wrecks is in question. To our mind it would be more practical to equip the man with a watertight knapsack, fitted with cells, somewhat after the fashion that Siemens adopted for the ballet girls at the Savoy Theatre when "Iolanthe" was being played. The idea of affixing an incandescent lamp to a diver's helmet is credited to M. Marcillhazy, of Paris. Mr. Applegarth also showed and described the Denayrouze respirator, in combination with the upper half of a diver's dress and helmet, fitted with an electric lamp for use in ascertaining the seat of a fire in a ship's hold, when as yet there was more smoke than fire.

Messrs. Spiers and Pond.—This enterprising firm have nearly completed large stores near the Ludgate-hill Station, which will be lighted electrically, and from what we can gather this should prove to be a model station of its kind. The machinery is placed in the sub-basement, and consists of five of Willans and Robinson's G G engines, driving Edison-Hopkinson dynamos made by Mather and Platt, of the same model as that illustrated in our last issue, and one C E engine by the same makers driving an Edison - Hopkinson machine of about 24,000 watts output. Steam is supplied from three 150-h.p. boilers, made by Messrs. Babcock and Wilcox at their Glasgow works. Great attention has been given to the arrangements for distributing the steam, and it will be practically impossible for an entire breakdown to occur, even should one-half of the steam main give way. The total capacity of the

station will be about 2,100 amperes. The cables outside the stores, which will supply Messrs. Spiers and Pond's other departments even as far away as Holborn, are being laid by the Callender Company, who are using their well-known lead-covered cable. There will be four pairs of cables, extending for a distance of about 700 yards. We understand that Messrs. Spiers and Pond will probably open their new stores about the middle of November, and by that date we suppose the station will be complete in all details. A trial run has already taken place with, so it is whispered, very satisfactory results. If everything works well in the future we shall have to congratulate Mr. Sidney Hargreaves, engineer to Messrs. Spiers and Pond, who has engineered the whole thing.

Electric Lighting in Baltimore.—The Brush Electric Company, of Baltimore, Md., is making additions to its already very extensive alternating-current electric lighting plant, which will give it a total capacity of 20,000 lamps of 16 c.p. each, and will make the Baltimore central station plant one of the largest alternating-current incandescent lighting plants in the United States. It was in the early part of 1887, a little over three years ago, that the Brush Company made the first contract with the Westinghouse Electric Company for the installation of alternating-current apparatus aggregating a capacity of 5,000 lights. The undertaking was then looked upon as more of an experimental test of the new Westinghouse system than anything else. The Baltimore Company had been frequently urged to extend its system of lighting all over the city, but the management had not been able to comply with this demand, because the electric lighting system in operation would not enable them to cover any large territory without the putting up of several additional power houses. In other words, it was not suitable for long-distance lighting. But as the Westinghouse Company claimed for its alternating-current system that it was especially adapted to cover a large area in a safe and yet economical manner, it was thought advisable to try it. From that time the popularity of the new system was in Baltimore an established fact. The demand for the new light grew at an enormous rate and before long the company was compelled to increase its plant. The Westinghouse Company was called on for additional apparatus of 3,000 lights capacity. But even this did not long satisfy the demand, and twice again the company increased its capacity by 3,000 lights, until at the beginning of the present year the central station plant had a total capacity of 14,000 alternating-current incandescent lights. This last addition has been necessitated on account of the demand which has been made on the Baltimore plant, and when the installation is completed there will be but two cities in the country with larger capacities of alternating-current incandescent lighting apparatus—Pittsburgh with 60,000, and New York with 50,000.—*Electrical World.*

Exeter.—A conference has been held between the directors of the Exeter Electric Light Company and a committee of the Town Council, with reference to the former's application for an order, but neither have been able to come to terms. The committee reported to the last meeting of the Council that they were of opinion that the terms upon which the Council should be able to exercise the right to purchase at a lesser period than 42 years should be, that in addition to the value of the plant and works to be determined by valuation upon the basis, and in manner prescribed by section 2 of the Electric Lighting Act, 1888, the Council should, if electing to purchase at the end of 14 years, pay a sum as goodwill equal to the net profits of the preceding five years, and if the option be exercised at the end of 21 years then that the net profits of the then preceding three years be added, and if at the end of 28 years the net profits of the then preceding two years be added. The directors of the electric light company replied to this proposal, through their solicitor, that they could not consent to clauses being inserted in the provisional order, giving the Council the option of purchase at a less term than 42 years, except upon the following conditions: (1) That such option shall not arise at less than 21 years. (2) That the basis of purchase be the repayment to the company of all capital expended by them, with, in addition, an amount equal to the net profits of the company for the preceding five years if the purchase takes place in the first 30 years, and of the preceding three years if it takes place between 30 years and 42 years. The committee stated that these terms they could not, under any circumstances, recommend the Council to accept. After considerable discussion, during which several different resolutions and amendments were proposed, a vote was taken on the question that the Council should themselves apply for a provisional order. This was carried by 20 votes to 16. It was also decided not to consent to the application of the company for a provisional order, and the town clerk was instructed to take immediate steps in carrying the resolution into effect. Verily the path of supply companies is not always a smooth one.

The Edinburgh Exhibition.—It has been officially announced that the letters of the guarantee fund of the exhibition have been hypothecated to the British Linen Company Bank in security of advances. This is accepted as a confirmation of the rumours as to the large deficit that the balance-sheet of the exhibition was likely to disclose. There is a general expectation that very little of the guarantee fund, said to amount to £25,000 or £30,000, will survive. On Tuesday last, in the Court of Session, Edinburgh, Messrs. Drysdale and Gilmour, contractors, of Leith-walk, presented a petition for the judicial winding-up of the exhibition association. The petitioners, who erected the exhibition buildings, stated that there was still a balance of £9,000 due to them, which the association, although called upon, had failed to pay. They stated further that the only assets were the guarantee fund and the exhibition buildings, which at the close of the exhibition must be broken up and sold. On the other hand, there were debts amounting to £43,961, including petitioners' debt and £20,000 advanced by the bank. The petitioners stated that the exhibition would result in a large deficiency and heavy loss to the creditors, and they asked the Court to appoint a judicial liquidator, in order to prevent the bank and other creditors obtaining a preference. On Wednesday Lord Young gave judgment, and said he thought that, without deciding anything about the propriety of the merits of this application for the judicial winding-up, they should grant the usual formal order for intimation and service upon the respondents. Their Lordships concurred. Answers were ordered to be lodged to the petition within eight days. On the same day Lord Stormonth Darling heard counsel in the Bill Chamber of the Court of Session in connection with a petition by Gilroy and Company, contractors, against the Edinburgh International Exhibition for intimation and service of the petition and interim interdict against that day's drawings at the exhibition being paid the British Linen Bank. After a discussion, interim interdict was granted on caution being found, answers to be lodged in 24 hours.

ELECTROLYTIC BLEACHING.

BY ALEXANDER WATT.

The great advances which have been made in the means of obtaining electric currents without involving the consumption of metallic zinc, as in the ordinary voltaic battery, have rendered many electrolytic processes commercially available now which had to be abandoned formerly, soon after their conception, in fact, owing to the unavoidable cost of the zinc, acids, etc., consumed in carrying out such processes in what may be termed the "old battery days." The first great practical advance which was made in this direction was due to Mr. Henry Wilde, whose magneto-electric machine, soon after its introduction, was adopted by Messrs. Elkington and other large firms, not only for depositing silver, but for the production of electrotypes of large dimensions, such as statues, for example, and subsequently for refining impure copper of the smelting works by electrolysis, a process of the greatest importance, and the success of which was the inauguration of a new scientific art, *electro-metallurgy*, a title which had been, up to that time, applied to the art of electro-deposition generally, but is now understood to apply to the purification of metals by electrolysis, or their extraction from ores by the same means, as distinct from the art of electro-deposition, commonly miscalled "electro-plating."*

Previous to the introduction of magneto and dynamo-electric machines, not only were electrolytic processes destined to failure on account of the high cost of the electric current obtained from voltaic batteries, but electric lighting—in which many costly attempts had been made to render this source of artificial illumination available—had to be abandoned from the same cause. Now that we can get our electricity cheaply—at least by comparison with the voltaic current—we find that processes which had been abandoned by their inventors solely owing to the cost of the current produced by batteries, and not from any practical defects in the processes themselves, have from time to time been reintroduced as absolute novelties. As an example of this kind of thing it will be only necessary to give the following extracts from a patent obtained by the writer's brother, Mr. Charles Watt, in 1851, to show the close resemblance between this invention and many subsequent patents, which have been based upon its essential details and claims. A review of Mr. C. Watt's specification will be useful to paper makers and others who may feel disposed, now that a "chemical corner" has been formed to raise the prices of the chief substances used in their manufacture—caustic soda and bleaching powder—to turn their attention to electrolysis as a means of frustrating the machinations of the "corner" men. It need not be said (Mr. C. Watt's patent having long since expired) that the process involved, which is a perfectly practical one, is now public property, and may be adopted by anyone.

Extracts from Mr. C. Watt's Specification.—"The third part of my invention consists of a mode of converting chlorides of potassium and sodium and of the metals of the alkaline earths into hypochlorites and chlorates, by means of a succession of decompositions in the solution of the salt operated upon, when induced by the agency of electricity. . . . The electricity first decomposes the chloride, the chloride being eliminated at one of the electrodes, and the alkaline, or earthy base, at the other electrode. . . . The liberated chlorine will, when it is set free, combine with a portion of alkali, or alkaline earth, in the solution, and a hypochlorite will be formed. . . . If I desire to produce a hypochlorite of the alkali, or earth, I continue the process until as much of the saline matter has been converted into a hypochlorite as may be required for the purpose to which the solution is to be applied. This mode of forming a hypochlorite of the alkalies and alkaline earths may be used for preparing a bath for the purpose of bleaching various kinds of goods; and the bath may be strengthened from time to time by the action of the electric current."

Now, in the above process we have pointed out for us all that is necessary to convert solutions of common salt, chloride of magnesium, or other alkaline or earthy chlorides into practical bleaching liquors; and these liquors, when wholly or partially exhausted of their chlorine, may be recuperated and again rendered active for bleaching purposes by simply passing the electric current through the spent liquors as occasion may require, these processes of bleaching and restoration of the liquors being carried on *ad infinitum*. Although much has been written and said to the contrary, there is really no specific reason why a solution of common salt should not be employed as the electrolyte, since the hypochlorite of soda which results from its decomposition by the electric current is an exceedingly powerful bleaching agent, and is not so destructive to vegetable fibres as a solution of hypochlorite of lime (ordinary bleaching liquor). Respecting the way in which the electrolytic bleaching may be conducted, the bleaching liquor may, of course, be prepared in a separate vessel, and after fulfilling its mission in the beaters or potchers, as the case may be, the exhausted liquors may be run direct into tanks fitted with the necessary arrangement of electrodes, and the current then allowed to pass until the liquors have again been converted into active "bleach." It is probable, however, that it might be found even more effective—suitable arrangements as to the fixing of the electrodes being made—to conduct the bleaching of the pulp, as is done in the ordinary way, in the beating engines direct. In such case the spent liquors of one engine would be transferred to the next, and so on through a series, each beater being of course provided with its set of electrodes and the current switched on as required. In cases where it is preferred to prepare the hypochlorite bleaching liquors in separate tanks, and to run the "bleach" into the beaters in the usual way, it might be convenient to conduct the electrolytic operation of preparing the hypochlorite liquors in an apartment immediately above that in which the beating engines are placed, in which case the bleaching solutions could be directly run into the engines below, the exhausted liquors allowed to flow into lower tanks, to be again pumped upward to the electrolytic department. By such an arrangement, where necessary, a continuous flow of hypochlorite solution could be kept up in the beaters of an uniform strength during the earlier stages of the bleaching, and towards its close the flow of fresh liquors could be suspended until the operation was completed by the liquor in the beater.

When bleaching some vegetable fibres, previously well boiled in caustic soda solution, by electrolysis, in warm solutions of common salt, decomposed by a moderate current, I have invariably found that the colour of the fibrous material exhibited a decided change in the direction of bleaching a few moments after the current entered the solution, and that the progress of the bleaching was exceedingly rapid, especially when the temperature of the solution was kept up to about 80deg. to 90deg. F. Any paper maker or calico bleacher who may feel disposed to test the practicability of the electrolytic method of bleaching can readily do so without involving any considerable outlay. The process itself, as before observed, is now public property, and involves no "patent rights." To put the process to a practical test, say, to produce 200 or 300 gallons of bleaching liquor at a time, all that will be required is a suitable wooden tank capable of holding the requisite quantity of a nearly saturated solution of common salt. Suspended in the saline solution will be a series of carbon plates, as "anodes," or positive electrodes, and a corresponding series of plates, which may be of sheet zinc, for the "cathodes," or negative electrodes, placed about 2in. or 3in. distant from the carbon plates. A dynamo-electric machine of moderate capacity, fixed near a suitable driving shaft, and connected by copper conducting wires to the electrodes, would practically complete the apparatus required for such a trial, and if ascertained quantities of pulp were bleached with the liquors produced by the electrolytic operation suggested, and the amount of current actually used in the operation taken by instruments provided for the purpose, the relative

* The term "plating" was originally applied to a process in which a plate of silver or gold was fluxed or soldered on to one or both surfaces of an ingot formed from an alloy of copper and brass, the operation being performed in a *plating furnace*. The compound ingot was afterwards rolled out to the required thickness, and the sheets thus produced were then manufactured into "plated ware," "Sheffield plate" being exceptionally good.

cost of the new method as compared with the ordinary method of bleaching could be readily calculated and determined. It should be stated for the guidance of those who may feel desirous of trying the electrolytic method of preparing bleaching liquors with a view to a more extended application of the system, that any of the dynamo manufacturers to whom they may apply for information as to the cost of a small trial plant, for example, will doubtless, if commissioned to supply such an instalment, furnish all necessary information as to the most suitable dynamo for the purpose, the amount of current necessary to decompose, say, one-half of the salt in an electrolytic tank of given dimensions. It may here be mentioned that it is not advisable to carry the decomposition of the saline solution much beyond this point—that is, to the extent only of about one-half of the salt in solution—and since the solution may be rechlorinated, so to speak, from time to time, after using, there is nothing lost by suspending the electrolysis when, say, about one-half of the salt still remains in an unaltered condition; and, moreover, as the presence of undecomposed salt does not retard the bleaching in any way, there is no practical objection to its presence. If, on the other hand, the electrolysis were to be pushed much further than the point named, the hypochlorite formed would in its turn be decomposed, involving a useless waste of electricity and a sacrifice of a portion of the hypochlorite of soda produced.

In the foregoing observations the object has been to direct the attention of paper makers and others to the importance of electrolytic bleaching as a substitute for the more costly and, it is believed, less effective "bleaching powder" method; and a brief outline of the former system has been given to enable manufacturers who may not have turned their attention in this direction, to consider whether it might not be worth their while to "try for themselves" whether or no the electrolytic process of bleaching is a system deserving of a more extended application, bearing in mind also that the process referred to was patented so far back as 1851, and is consequently, as before shown, public property. The first part of Mr. C. Watt's specification relates to the production of caustic soda by the electrolytic decomposition of a solution of common salt, and since this process may be rendered practically available now that our means of obtaining the electric current for large operations are virtually unlimited, the writer proposes to treat this subject in a future paper.

WHAT IS "EARTH"?

BY SYDNEY F. WALKER.

Probably no phenomena connected with electrical engineering require such careful study, and such a thorough mastery, as those we know under the generic name of "earth"; yet probably about none are there so many hazy ideas entertained by those with whom the term "earth" is an expression as commonly used as any phrase in our language.

In the writer's opinion, a true conception of what really constitutes "earth," will clear up the whole of the mystery attaching to the proper method of protecting not only buildings, but also telephonic and electric lighting plant from the destructive action of lightning. Probably the most correct sentence uttered by Dr. Oliver Lodge, in his crusade against the existing forms of lightning conductors, was that in which he said that "earth" was a geological question. For lightning currents, the formation of the strata, into which a conductor may lead them, must have a very great influence upon their ultimate behaviour.

In the early days of electrical science, as is well known, the earth was considered to be a reservoir of electricity of infinite capacity. Frictional machines and galvanic batteries were simply pumps for extracting electricity from Mother Earth; and you returned the electricity to earth when you had done with it, always provided it had not escaped there before it had performed the work for which you required it. Mother Earth would take up as much electricity also as might be poured into it, no matter where it came from, and was perfectly indifferent whether it was called upon to receive or to furnish electricity of a positive or negative sign, vitreous or resinous.

We now know, of course, that "earth," whatever may be its form, and whatever may be its condition, physically or otherwise, is merely a natural conductor, and obeys the same laws as other conductors in every respect. Whether electricity be a mode of motion of the ether, or even the ether itself, we now know that to generate it in any form work must be done upon or by some body, and that it can only apparently disappear just as matter apparently disappears when it is transferred into some other manifestation either of energy or the ether, and that in the process of this transference work must be and is done upon the body through which the electricity is passing, and that this is equally true whether the body be a copper conductor as large in diameter as one of the mooring hawsers of the old line of battle-ships, or the earth's crust itself, whatever form that crust may take.

One of the first ideas of "earth," that used with frictional machines—viz., a connection to the floor of the room by means of a chain—is probably responsible for a good deal of the confusion which prevails even to this day, and for the sort of "shibboleth" utterance that is in vogue where the term "earth" comes in. Two amusing instances came under the writer's notice that forcibly illustrate the hazy notions prevailing, at any rate in some quarters, as to the nature of electricity generated by friction. Many people believe even now that the atmosphere contains electricity, not as electricians understand it, generated by clouds either in the process of formation or by friction with the atmosphere; but as something on top, resembling a reservoir of water that anybody can take a supply from if he only knows how. In the two instances that will be related, the extreme dryness of the atmosphere led to two opposite results—in the one case to what may be called a dearth of electricity, in the other to plenty. The first case occurred in the North of England. A pitman had saved some money and taken a public-house. To add to its attractions he had made a glass frictional machine, with which he used daily to amuse his customers. One very dry summer, however, the machine refused to work. "Tam," the owner and maker, tried all he knew on it, but had to confess himself beaten until the dry weather ceased, when it resumed operations; and the man who related the story to the writer expressed his opinion that during very dry weather there was not so much electricity in the atmosphere, so to speak, and that that was the reason "Tam's" machine would not act.

A little consideration will show that it was faulty "earth" which was the cause. It is well known that unless one side of a frictional machine is connected to "earth"—in this case the floor—it will only furnish a small charge, and that when so connected it will go on furnishing charge as long as the plate is revolved, provided the insulation of the machine is perfect. In the early days of the science the floor represented Mother Earth, which, possessing an inexhaustible supply, gave it up as required; and apparently there would be no reason why it should refuse to give its usual charge, no matter how dry the atmosphere, unless the charge was really taken from the latter in some mysterious manner.

We now know, of course, that the so-called connection to earth is merely a connection to the other side of the inductive circuit, the other coating of the condenser, if you will, consisting in this case of the film of moisture upon the floor, the walls, etc. Now, during this very dry summer the film was either quite absent, or, if not, it was so much reduced as to increase the resistance of the conducting path formed by it so much—under the conditions, say, with the imperfect contact usually thought sufficient—as to practically break the circuit. In the other case mentioned the travelling correspondent of the *Pall Mall Gazette* mentioned, among other properties of the atmosphere of some parts of Canada, during the depth of their very cold winter, that it was very rich in electricity. You had only to rub your slippers on the carpet, and you were able to light the gas with your finger. That is to say, a spark passed from your finger to the burner, igniting the gas when turned on.

Assuming this to be correct, of course, the explanation

has again only to do with the state of the atmosphere in as far as its excessive dryness renders it a good insulator. There would be a fairly good conducting path between the feet of the operator and his finger, by way of the moisture exuding from the pores of his skin—a much better path, at any rate, than could be found anywhere else; so that his charge which he generated would have no means of escaping in the exasperating manner experimenters with frictional apparatus are so familiar with—say, over the carpet to the walls of the room, and thence to the gas burner, which would form part of the other coating of the condenser, of which his body formed one. So that when he presented his finger to the gas burner, he presented a blunt point in connection with one coating of the condenser to a blunt point in connection with the other coating; hence the spark. Here, it is evident, that faulty earth was again the cause.

When using the electrophorus, it will be remembered, "earth" is the finger of the operator. When charging a Leyden jar or other electrical condenser, one coating is always put to "earth" by being connected to or allowed to rest directly on the table which supports it. In both these cases the earth connection is merely, as before, a connection to the other side of the inductive circuit. With lightning conductors, "earth" assumes most varied forms, from a tombstone into which the end of the conductor is leaded or a bottle resting on the stone, in which the end of the conductor is allowed to repose; to a large copper plate buried in moist ground, or in a pit into which a load of coke has been tipped.

Perhaps the most instructive lessons in this matter come from the use of "earth" as a return conductor in ordinary electrical engineering work. For small telegraph or telephone currents, for instance, earth of comparatively high resistance may be used, where only a single wire is joined the same pair of earth connections; but if a number of wires are all connected to the same earth at any particular station, unless earth there is remarkably good, the path for the current through earth back to the battery from which it started, being only one of many paths open to it, may not offer so much less resistance than that of the other paths through other wires to other earth connections, and thence to the original starting point, as to preclude portions of the incoming current from finding their way into the other wires, and working any apparatus that will respond to their feeble force. In fact, much of the cross talk between telephone lines, in telephone lines using "earth" returns, is due to this cause, and even indicator discs will often drop when they are not intended to, through the return split from some incoming current not properly led off by "earth."

It need hardly be pointed out that good earth depends upon the surface of conductor that is in contact with the conducting medium in the earth's crust, and that the continuance of good earth depends upon perfect contact being maintained between the conductor and the conducting medium. In nearly every case this conducting medium is water or liquid of some form or other which is either present in a large body, as in the case of a river or canal, or is held in suspension among the grains of soil, within the pores of rock, etc. As moisture is always present in the soil, even in the hardest rocks, it follows that there must be a path for an electric current through that moisture in every direction, and the only question that can arise in the matter of earth for any purpose, is that of securing contact with such an area of soil, rock, etc., as will embrace enough moisture to give a sufficiently low resistance between the points the current is to pass across. Agriculturists are familiar with the fact that a sharp frost breaks up the ground better than any manual labour can do, and it is well known that this breaking up is accomplished by the expansion of the water held in, or perhaps holding the soil, in the act of freezing; the grains of soil being freed again and well divided after the thaw which follows. Electrical engineers who have used "earth" for natural circuits are also familiar with the fact that this wonderful provision of nature, so good for the former, is a great nuisance to them, as it often so increases the resistance of their earth circuits as to cause their instruments to cease working, the increased resistance being due to the difference between the specific resistance of water in the liquid and in the solid state.

Water is not always the only conductor available for earth. Coal, for instance, appears to act as a conductor of high specific resistance, and it is probable that veins or pockets of metalliferous ore would do the same, though the writer believes no measurements have been made of any of them. Again, it is very doubtful if a really efficient "earth" can be obtained anywhere for a large electric lighting or power current unless the bed of a large stream be near both points between which the current is to pass. The "earth," so called, which is formed by the skin of the ship, where the single-wire system of wiring for electric lighting on board ship is used, is not proper "earth." It is merely a large metallic conductor available at all points, supported, if you will, by the water in which the ship floats

Again, with dynamo machines of high tension, it is usual to express the fact that the dynamo is not perfectly insulated by saying it is making "earth," and this is quite correct. Some portion of the current generated is actually passing, by way of the frame of the machine, to the moisture in the flooring and other adjacent objects, and the unfortunate individual who receives a severe shock by accidental contact with some other metallic portion of the circuit owes the shock to the fact that the dynamo itself is making "earth." Perhaps this form of "earth" presents as interesting a study as any one meets with. "Earth" is really "earth" here. It is performing its proper function of a return path for the current. The latter, setting out from the dynamo, passes along the wire to the operator who knowingly or by accident has exposed his bare flesh to a bare metallic portion of the circuit, thence by way of the moisture on his skin, the moisture, liquids, etc., in his body, to the moisture on and in the ground, and thence by way of the moisture in the ground, assisted by any conductors, such as gas or water pipes, coal beds, etc., that lay in its path, back to the foundation of the dynamo, and through the frame to the point of departure. The current which passes in this case is very small. It may be so small that it would be difficult for any of the instruments used in practical electrical engineering to record it; though if the operator happens to break the circuit, as some man in America did who tried to start an arc lamp that had gone out, the current will be considerably increased by the E.M.F. due to the self-induction of the coils of wire on the dynamo.

The injury done to the operator is due to the fact that the human body can only stand a very small current without excessive heat being produced, or a dangerous contraction of certain muscles that may cause the cessation of the heart's action.

But it must be clearly borne in mind that this "earth," which is of sufficiently low resistance to seriously injure a man, to even kill a huge quadruped, or is even sufficient to prevent certain apparatus from working, is not sufficient to protect the operator. Connecting the identical piece of metal, which the unfortunate operator touched, to the ground on which he stood by a conductor of as large proportions as you like, will not protect him in the smallest degree unless the connection be so, and the whole circuit be so that the E.M.F. between the point touched by the operator and the ground on which he stands is brought below the danger figure, that at which a dangerous current can pass through his body.

The same remarks apply to the protection of telegraph and telephone instruments, and of electric light plant, from the action of highly-charged thunderclouds. Once the wire leading to an electrical apparatus is struck by a current—either directly from, or induced by, a thundercloud—and there is any passage to earth, as there invariably is, through the apparatus, there is only one way in which the apparatus can be protected by an earth connection—viz., by making that connection in such a manner, and part of such a circuit, that the E.M.F. of the destructive current outside the apparatus, is thereby reduced below that which would cause a dangerous current to pass through the coils of the apparatus it is designed to protect. It must be remembered that, both in the case of the man standing on the ground touching a bared portion of a high-tension electric light plant, and in the case of a telegraph or telephone instrument which it is desired to protect from lightning, the man and the coils

of the instrument form derived circuits to earth, parallel with the protecting path where one exists, and will take current in proportion to the E.M.F. present, and in inverse proportion to their resistance, and that of their earth connections, as if the protecting path did not exist; just as a number of incandescent lamps will take current from a pair of cables, between which an E.M.F. exists, exactly in the inverse proportion of their resistances, and without reference to each other except in so far as their joint presence tends to lower the E.M.F. available for each. This same reasoning applies to the instances of side flash which have been unhappily so frequent, and which have led Dr. Lodge to the conclusion that "earth," if not actually bad for a lightning conductor, is at best a doubtful blessing. The side flashes, it will be noticed, have invariably been to gas brackets, or to some conductor connected directly or indirectly to earth; and the flash itself has been due to the fact that an E.M.F. existed at the point of the lightning conductor nearest to the bracket or other object to which it flashed between it and the "earth" to which a path led by way of the object, and that this E.M.F. was of sufficient magnitude to drive a current in the form of a spark across the intervening air space, and through the object to "earth." The problem, after all, of protecting buildings from lightning, or at least an important part of it, is how to expend the energy of the thundercloud so that no dangerous E.M.F. may exist in a position to throw sparks to other conductors leading to earth, in which, as in gas-pipes, the current may do serious damage. This would lead to the recommendation that all gas and water pipes, and all metallic conductors leading to earth, directly or indirectly, should be connected to the main conductor, were it not for the fact that this plan might defeat its own object by rendering it certain that whenever a conductor was struck a portion of the lightning current would go by each of the paths so provided, and that in its passage any such portion might meet with some local resistance, such as a white-leaded gas joint, that would cause it to generate sufficient heat to ignite the gas, or that a minute air space might be in its path, not of sufficient size to bar its progress, but sufficient to cause a spark with its attendant troubles.

In the writer's opinion much of the damage which is done by lightning is due to the intense heat generated by the spark or flash, which often suddenly converts the moisture held in bricks or stones into steam. The sudden expansion of a body previously held in the pores of a coping stone, for instance, into a vapour 1,700 times its original volume, will account for a good many of the terrible accidents recorded. The whole bearing of "earth" upon the problem of the safe discharge of a thundercloud, and of the best method of protecting buildings, etc., from the destructive effects of lightning, the writer hopes shortly to discuss in another article, as the subject is too wide to be included in the present one.

RECKENZAUN'S IMPROVED METER.

The features claimed for this new Reckenzaun meter illustrated in the cuts are sensitiveness and an absolutely accurate measurement of the electricity consumed.

The device consists essentially of two solenoids actuating iron cores, A and B, which are connected with a lever, L. This lever is pivoted at O upon a standard and carries at its furthermost end a friction roller, R, which is supported from the forked end of the lever by means of two small links, P, pivoted at their upper ends to the fork of the lever and at their lower ends to a collar, mounted loosely around a sleeve on the roller, R. The object of this mode of suspension is to allow complete freedom of motion to the roller up and down the vertical spindle, S, which is connected at its upper end to the registering or indicating mechanism. Since the end of the lever describes an arc while the path of the friction roller is in a vertical straight line, this highly flexible mode of suspension is of great importance in eliminating friction. The lever, L, is balanced by a counter weight, as shown, in such a manner that the roller, R, will just drop down towards the centre of a disc, D, when no current is passing through the solenoid. As soon as a small current is allowed to circulate through the solenoids the core B will be sucked up to a slight degree corresponding to the strength of the current. Core A simultaneously drops down as a result principally by gravity.

The highest portion of the lever is shown by dotted lines in Fig. 1. This would correspond to the greatest current the instrument is intended to indicate, and in this position the friction roller will be near the circumference of the disc, D, and will therefore transmit its greatest velocity.

Fig. 1.—Reckenzaun's Improved Meter.

The disc, D, is revolved at a constant speed by the clockwork shown to the right in Fig. 1. In order that the roller, R, may rise and fall readily with any variation of current, a portion of the face of the disc is cut away, Fig. 2.

It may be stated, in order that the action of the meter may be more easily understood, that the distance through which an iron core travels within a solenoid is not absolutely proportional to the current flowing within the coil.

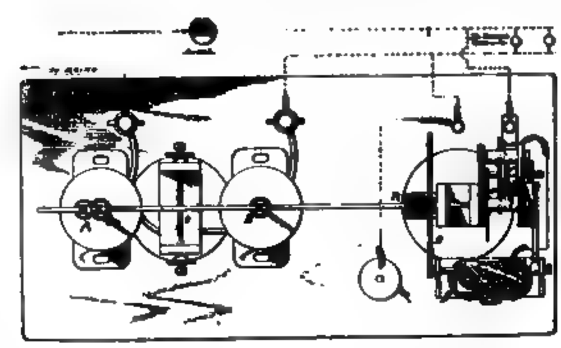


Fig. 2.—Reckenzaun's Improved Meter.

In this meter, however, it is quite essential that the radial displacement of the roller, R, relatively to the disc, D, should be proportional, because the consumption of electricity has to be recorded by the velocity with which roller, R, revolves and communicates its motion to dials similar to a gas-meter. Thus the function of the second solenoid and core A is to compensate for the varying attractions upon B, and also to equalise any "magnetic lag" which might be appreciable and involve slight errors. Both solenoids are energised by the same current, and the tendency of core B being sucked up at a greater distance than that corresponding with the increased quantity of current is counteracted by the core A, whose gravitation effect is reduced simultaneously, since there is also here the natural tendency of the core being held level with its solenoid. The core A will keep dropping down so long as its weight is greater than the effect of the solenoid trying to hold it up; but as the current is increased there will be a point when A will actually be held up by the solenoid, and all tension on its suspension cord or chain, C, destroyed. After this occurs the core B has alone to do the work of raising the lever, and for this reason core B is suspended by a rigid rod, G. A plan of the meter is shown in Fig. 3.—*Western Electrician.*

Fig. 3.

THE

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Specimen copies of the paper will be sent on request.

PREPARING FOR THE FIGHT.

It would not add to the success of agitation if at all times the truth was told. No doubt the telephone interests are, as indicated by the *Financial News*, "preparing an agitation against the Government monopoly in telephones," and that this "is being vigorously worked." The same authority thinks the agitation "ought to succeed." Well, opinions differ very considerably upon the point. We prefer to add one word to our contemporary's expression, and say the agitation "ought not to succeed." Mr. Gladstone, when discussing the McKinley tariff at Dundee, referring to the increased effect of the tariff upon worsteds of the poorer sort, spoke of it as "a monstrous injustice to the mass of the population." He admitted that a small band of manufacturers would benefit, but it was at the expense of the general population. Now, we contend that any English Government is bound to consider whether the giving up the telephone monopoly, which is legally the property of the Government, bought and paid for by taxation, is not as glaring an attempt to benefit the few at the expense of the many as the McKinley Tariff Act in America. The facts of the case are simple, and should be kept in the front of the fight. The Government—that is, the nation—thought it advisable to buy the telegraphic system of the country. Subsequently telephony was developed, and telephony has been legally construed to be telegraphy under another name, and the nation having the monopoly of telegraphy have therefore the monopoly of telephony.

If any benefit is to accrue from the general adoption of telephony the taxpayers should have it, and to allow the benefit to go in any other direction "is a monstrous injustice to the mass of the population." No Government dares to fall in with the desires of the agitators. Up to the present time the Government has been content with a royalty. The extension of telephony means increased competition against what is known as telegraphy. Only a close examination of balance-sheets would show whether the increased royalty for telephony was the equivalent to the decreased receipts from telegraphy. One point must not be forgotten, and it is one most frequently left out by those who do not want people to know the true facts. The argument is often used that telegraphy has increased, although telephony has come into vogue. The question is not has it increased, but has it increased to the same extent as it would have increased if there had been no competition? By whatever amount the receipts have been decreased by competition, that amount the nation has lost unless it is made up by the royalties received. Even if the royalties recoup the losses, still the nation is the loser by the profits obtained in telephonic work after deducting the royalties.

Our readers must not be mistaken. We care as

Electrical Engineer

'IEW OF MACHINE ROOM.

'IEW OF MACHINE ROOM.

COLCHESTER.

Last week an installation on the premises of Messrs. Evatt Sanders and Son, at Colchester, was started by Lady Brooke. The installation has been carried out by Messrs. Christy, Son, and Norris, of Chelmsford.

The plant is an interesting one in several ways. The dynamo is driven by an Otto gas engine of 7 h.p., which is also used for other work. The engine is fitted with the electric light governor and tube ignition.

The dynamo is wound for 65 amperes and 125 volts, and fitted with a heavy disc flywheel.

The switchboard is of a very ornamental character, is fitted with two ammeters; voltmeter (gravity, Evershed's); and double five-way switch; automatic switch (Electric Construction Corporation); starting switch, and the switches and cut-outs for four main distribution circuits. The whole being mounted on polished mahogany board, 3ft. 6in. by 2ft. 6in. All connections at back.

The starting switch was specially designed for this plant, and answers admirably. The dynamo starts the gas engine in 10 or 12 seconds, the maximum current being 35 amperes, diminishing to 30.

It is a two-way switch, coupled in such a way that in one position, while charging, the resistance is short-circuited, and the shunt circuit (magnets) passes through it and receives full P.D. of brushes. When the plant is standing and automatic switch open, reversing the switch puts full P.D. of cells to magnets and the armature current passes through resistance coil.

The engine-room has oak panelling all round, with plate glass above. On three sides it is filled in with very pretty tiles.

There are 54 23L glass cells arranged in two tiers in a well-ventilated room with a simple traveller arrangement overhead. They are always in circuit, as the supply is constant, the dynamo working in parallel during the evening.

One of the four circuits supplies the wholesale establishment with 35 lights. The second supplies a 3½-h.p. motor, and four lights in the stables 170 yards distant (the motor cuts chaff and crushes oats), also 13 lights to Mr. Hopwood, jeweller.

The third circuit supplies the St. Runwald's Club with 40 lights, and the fourth supplies 45 lights in the retail shop 100 yards distant. In this shop are also a 1,200-c.p. arc lamp and a ½-h.p. motor fitted upon a stand in connection with a coffee mill for grinding coffee in the window.

After the opening ceremony, Lord Brooke, replying to the vote of thanks to Lady Brooke and himself, said that recently, while staying at a small fishing village in Sweden, he found the village lighted entirely by electricity, and he hoped it would soon be more extensively used in England.

AN ELECTRIC TRAMWAY IN BREMEN.*

The opening of an electric tramway meant for serious work in a big town is not an everyday thing. On this side of the Atlantic, tramway companies have been somewhat slow to find out that increased profit could be derived by substituting electric power for horse power.

It is the more important, therefore, when a large town energetically tackles the problem and makes a start, and it becomes doubly interesting if such a town adopts a system which is working successfully in America, but here is condemned as unsuitable for large towns with heavy traffic. Every tramway director, whether he serves municipal authorities or private companies, is bound to watch with the keenest interest any step taken by others in this matter, and one successfully established and working line will draw ten others after it.

It is the rival of Hamburg, the growing town of Bremen, in Hanover, which has the honour of having made such a start, and the system it has adopted is that of the Thomson-Houston Company, as is now developed under the patents of Van de Poele and Bentley-Knight.

* From the *Rundschau*.

The line on which thousands of passengers are daily carried goes through the most crowded thoroughfares of the city, and is about two kilometres long. The current is taken from an overhead conductor to the car, and returns to the generating station through the rails. The voltage used is 500 volts. All the cars are thus in parallel on a 500-volt circuit. The overhead conductor consists of two bronze wires, carried at a height of six metres over the middle of the rails. Along the sides of the streets high cast-iron posts are placed for street lighting purposes, and from these the conductors are supported and kept properly taut by mean of iron wires.

Where branches reach the main line the shunt conductors are connected to the mains by means of bronze connecting pieces.

Over the conductors is suspended a net of iron wire so as to prevent falling telephone wires coming into contact with the conductors. This double set of network is, of course, no embellishment to the streets, but people seem not to take any notice of it after a few days.

The current is brought to the car through a long jointed rod resting on the front part of the carriage roof. The rod carries at its top end a bronze wheel, which makes the contact. As might be expected, the rolling contact at top and bottom of the car through the rod wheel and the running wheels of the car gives rise to considerable sparking, which is visible even in the day time, and the current in leaping across causes a whistling note, the pitch of which increases with the speed. Meanwhile, this seems not to be any great drawback, and the public are very pleased with the precision of the traffic and the exactness with which the driver can control the car. The speed is governed by means of resistances, and the celerity with which a fully-loaded car—weighing about 6,500 kg.—can be stopped, even when going at full speed, is remarkable.

This gives two advantages: Firstly, the cars can be run very closely upon each other when the traffic requires it without risk of collision, should the one in front stop without giving notice. Secondly, the cars can stop immediately any passenger gives a sign, which in wet weather and dirty walking is a great convenience to the public.

The carriages are lighted electrically by a shunt current.

Altogether the enterprise has up to the present given great satisfaction.

THE WESTINGHOUSE ELECTRIC RAILWAY MOTOR.

Ever since the Westinghouse Electric and Manufacturing Company made the announcement of its intention to commence the manufacture of electric street car motors, those directly concerned in the progress of electrical achievements have been interested in the apparatus brought out by the company. From the accompanying cut, Fig. 1, it is at once discernible that the motor employed by the company is of solid mechanical construction, which is of especial importance in a street car motor on account of the unusual wear and tear to which it is constantly subjected. Otherwise the motor does not seem to have any radically new features; in fact, one is inclined to assume that the company's intention was not principally to manufacture a motor totally different from those already in use, but rather to design an apparatus the chief characteristics of which should be simplicity, strength, and, above all, durability.

The motor is series wound, etc., and designed for a constant-potential 500-volt direct current circuit. Armature and fields are in series with a set of "diverter" coils, which are used when the cars start, and also to vary the speed. For its foundation the motor has a continuous iron frame, upon which all the bearings are placed; in fact, its chief object is to hold all the mechanical parts of the motor together and keep them in the same position in which they were arranged when the motor was put together in the company's works.

The field magnets are supported by this frame, and they are constructed upon hinges in such a manner that an armature may be taken out and a new one substituted in a

license, I am directed by the Board of Trade to transmit to you the enclosed copy of Major Cardew's report of his recent inspection of the electric lighting installation at Bath.

With regard to the suggestion made in the final paragraph of your letter, I am to inform you that the Board of Trade would not be prepared to insert clause 54 of the deposited draft license in the license when made, as they are advised that its insertion would create much confusion and would render the license unworkable.

The Board of Trade would be willing, however, to consider the expediency of inserting a provision enabling the local authority to purchase the plant at the expiration of the license, if the license were not renewed; and I am to forward, for your observations, a clause drawn for the purpose of giving effect to this proposal.

BATH ELECTRIC LIGHTING LICENSE.

Board of Trade.

Sir,—With reference to your letter of the 17th instant on the subject of the above-mentioned license, suggesting certain amendments in the clause relating to the purchase of the undertaking by the local authority, I am directed by the Board of Trade to inform you that they are prepared to consider the expediency of inserting a clause in the terms of the accompanying draft, but that they cannot consent to the omission of the proviso at the end of the clause.

I am to add that a renewal of the license would not be effected until the local authority had had an opportunity of expressing their views.

I am at the same time to return herewith the letter from this department of the 15th inst., which was enclosed in your letter of the 17th inst.

PURCHASE OF PLANT, ETC., BY LOCAL AUTHORITY.

65A. The local authority, if they think fit, may by notice in writing to be given not more than 12 months nor less than six months before the expiration of the term of this license, require the undertaker to sell, and thereupon the undertaker shall sell to them all land, buildings, works, material, and plant suitable to and used by him for the purposes of the undertaking, or such of the same as shall be specified in the notice, at a price to be determined, in default of agreement, by arbitration, and from and after the expiration of the said term or a subsequent date to be fixed in like manner the said land, buildings, works, material, and plant so purchased shall vest in the local authority freed from any debts, mortgages, or similar obligations of the undertaker or attaching to the undertaking; provided that the said notice shall not have effect if this license is renewed by the Board of Trade.

ON THE AIR CONDENSERS OF THE BRITISH ASSOCIATION.*

BY R. T. GLAZEBROOK.

(*With a Note by* DR. A. MUIRHEAD).

The question of issuing certificates of capacity has from time to time been discussed by the committee. The following paper gives an account of some experiments that have been in progress during the past two years with this object in view:

In the report for 1887 the committee express the opinion that it is desirable to proceed with the construction of an air condenser. In conformity with this opinion a meeting was held in London, at which Dr. A. Muirhead exhibited an air condenser consisting of a series of concentric brass cylinders insulated by glass rods, which appeared to the committee to possess great merits; and it was decided that the secretary should test this and two similar condensers which Dr. Muirhead offered to lend, before proceeding further with the construction of condensers for the association. The tests were carried out with satisfactory results.

The capacity of each condenser was determined repeatedly, using the method of a vibrating commutator, due to Maxwell, already employed by J. J. Thomson, *Phil. Trans.*, 1883, and Glazebrook, *Phil. Mag.*, August, 1884. The values found were

$$C_1 = \cdot 0030514 \text{ microfarads.}$$
$$C_2 = \cdot 0031258 \quad \text{,,}$$
$$C_3 = \cdot 0033288 \quad \text{,,}$$

It was found that the capacities remain constant from day to day, and that the accuracy of a single determination was about 1 in 1,000, although the capacity to be measured was so small.

A mica condenser belonging to the Cavendish Laboratory was compared with these—details of the method will be given shortly—and it was found that when comparing a condenser of one microfarad with the three air condensers combined, having thus a capacity of ·009506 microfarads, so that the ratio of the two was about 100 to 1, an accuracy of about 1 in 1,000 was attained. It was also shown that the capacity of the mica condensers as thus found, differed by nearly 2 per cent. from its value as determined by the rapid commutator, thus proving that the commutator method was unsuitable for a condenser showing absorption.

* Presented to the British Association as an appendix to the report of the Committee on Electrical Standards.

Thus for three mica condensers the following values were found.

With commutator.	By slow method of comparison.
·9690	·9868
·4934	·4994
·09543	·09644

These results make the necessity for an air standard all the more apparent. A report on the experiments made up to that date was laid before the committee at a meeting in London in April, 1889. It was then decided to adopt Dr. Muirhead's form of condenser, and to have two made on the same pattern for the association. These have been constructed by the Cambridge Scientific Instrument Company, following Dr. Muirhead's plan, but on an enlarged scale. Each has a capacity of about ·02 microfarads, or about six times that of one of the original condensers.

FIG. 1.

Fig. 1 shows the arrangement. The condensers consist of 24 concentric tubes. The outer tube is about 2ft. 9in. high and 6in. in diameter. Each succeeding tube diminishes in diameter by $\frac{1}{8}$in. The tubes are about $\frac{1}{32}$nd of an inch in thickness, and the air space between the inside of one tube and the outside of the next is about $\frac{1}{32}$nd of an inch, but it was found impossible to get all the tubes of exactly the same thickness, so that in some cases the distance between the tubes is less than the above. The tubes are carried by two conical brass castings. The outside surface of each casting forms a series of 12 steps, over which the successive tubes fit. Each tube is held in position by screws. The upper cone is supported by the outside casing of the condenser, and 12 of the tubes hang vertically from it. The lower cone is carried by three ebonite pillars, about 3in. in height; the 12 tubes which are attached to it come respectively between those which are suspended from the upper cone. Thus the insulation depends on the ebonite pillars, assuming there is no leakage across the air from the edges of the tubes. There is an opening in the outer casing, closed by a door, by means of which the ebonite can be cleaned; the whole is dried by placing inside a small vessel of sulphuric acid. In the centre of the upper cone there is a hole through which a rod passes. The rod is connected with the lower cone, and forms the electrode for the insulated cylinders. An ebonite plug, fitting tightly round the rod, can be pushed down so as to close the hole and prevent the ingress of dust when the condensers are not in use; when they are being used the plug is removed.

The condensers are placed in the testing-room at the Cavendish Laboratory and covered by a wood and canvas case to protect them from dust. It is not intended that they should be movable.

After this description of the condensers we will proceed to an account of the tests to which they have been subject. The first test was for leakage.

One set of cylinders was put to the earth while the other was connected with a gold leaf electroscope. An attempt was then made to charge them with an electrophorous or a small electrical machine, but this failed entirely. The electricity either sparked across at places where the tubes were very close together, or before the potential rose sufficiently to affect the electroscope small fibres or dust particles which adhered to the tubes formed leaks across; it was clear that the condenser could not be charged to the potential of the machine. Tests were then applied for leakage when the potential was lower. One set of tubes were connected to one pole of a battery—about 36 storage cells were generally employed, having an E.M.F. of 75 volts—the other set being in connection with an insulated key, the second pole of the battery was connected through a galvanometer to the key and the condenser charged. After an interval, usually about five minutes, contact was again made at the key, the deflection of the galvanometer needle—assuming the E.M.F. of the battery not to have changed—was a measure of the quantity of electricity which had leaked from the condensers in five minutes.

The amount of leakage was very different in the two condensers, and depended greatly on the dryness of the air and ebonite pillars. Thus, on March 11, when strong acid had been enclosed for some time for condenser I., the leak per one minute amounted to about ·1 per cent. of the whole charge, while with condenser II. it was about 10 times as great.

The sulphuric acid was removed during the Easter vacation and replaced by calcium chloride, and after this the leak in I. rose to about 1 per cent. per minute or 10 times its former value, while that in II. was from 3 to 4 per cent. of the charge. With the calcium chloride inside, the leak was never reduced to less than about ·8 per cent. per minute. In August, the condensers having been closed since June, with calcium chloride there was a leak in I. of about 3 per cent. per minute, while in the same time II. lost about 8 per cent. of its charge.

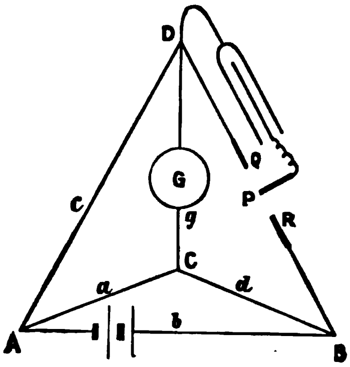


FIG. 2.

On August 14, immediately after this test, the calcium chloride was replaced by sulphuric acid, and the leak was quickly reduced to about 1 per cent. per minute for I. For II. no improvement showed itself at once. The next day the leak in I. was about ·4 per cent. per minute, that in II. had not been greatly reduced. On August 16th the ebonite was, therefore, well cleaned, and air was blown through the tubes of II., and the whole closed for about two hours; the leak had then fallen to about 2 per cent. per minute. By August 18th the leaks were still more reduced, that in I. being ·2 per cent. per minute, while that in II. was ·6 per cent. per minute.

By the afternoon of this day the upper parts of the condensers having been open to the air of the laboratory for some six hours during other tests, the leaks had appreciably increased, but they had fallen again the next day when the condensers were left closed during the night.

Thus, during the observations in August, with the exception of those on August 14th, the condenser I. was losing its charge at the rate of about $\frac{1}{500}$th part per 1 minute, while the leakage in II. was some five or six times as great, being about $\frac{1}{100}$th part of the charge per 1 minute.

As will be seen later, several mica condensers were compared with I. and II., the leaks in them were all small, and did not exceed more than $\frac{1}{500}$th per minute.

We come now to the experiments for determining the capacities of the two condensers. Of these, three independent series were made—viz., in December, 1889, May and June, 1890, and August, 1890.

The method already referred to was used Fig. 2 gives a diagram of the method; in Fig. 3, the connections actually employed are shown. With the notation employed, *Phil. Mag.*, August, 1884.

We have, if C be the capacity of the condenser, n the number of times it is charged per 1 second,

$$nC = \frac{a\left\{1 - \frac{a^2}{(a+c+g)\,(a+b+d)}\right\}}{cd\left\{1 + \frac{ab}{c\,(a+b+d)}\right\}\left\{1 + \frac{ag}{d\,(a+c+g)}\right\}}$$

In most of the experiments about to be described we had the following values:

$$a = 10 \qquad d = 1{,}000$$
$$b = 18 \qquad g = 17{,}600$$

in legal ohms, while c, which was the adjustable arm, varied from 6,000 to 15,000.

With these values, the only correction which need be included is the last factor in the denominator, and we may write

$$nC = \frac{a}{cd\left\{1 + \frac{ag}{d\,(a+c+g)}\right\}}$$

The resistances were taken from a legal ohm-box belonging to the laboratory. The various coils in this box were carefully

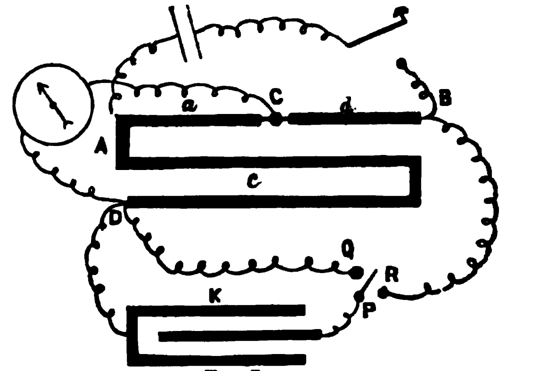


FIG. 3

compared with each other by Mr. Searle, and found to be consistent with each other, at any rate, to within 1 in 10,000. The coils were also compared with the standards of the association, and it was found that at 16deg. they were greater than legal ohms in the ratio of 1·0011 to 1. The standard temperature adopted in the experiments was 17deg., and since the coefficient of increase of resistance of the box is about ·0003 per 1deg. C., the resistances require to be multiplied by 1·0014 to reduce them to legal ohms. In some cases, in the value of c, coils from a B.A. unit-box, containing coils of 10, 20, 30, and 40 thousand, B.A. units were employed.

The values found for these coils by myself in terms of the legal ohm-box showed that they were very consistent with each other, and that the nominal 10,000 B.A.U. was equal to 9,880 legal ohms as measured by the legal ohm-box.

In the comparisons of two condensers certain coils from a megohm-box were used; the value of each of these was also determined. They were as follows:

1	98,731	Legal ohms of standard box.	
2	98,625	,,	,,
3	98,698	,,	,,
4	98,735	,,	,,
9	98,725	,,	,,
10	98,776	,,	,,

In the experiments on Dr. Muirhead's condensers, the vibrating commutator described in Prof. Thomson's paper, *Phil. Trans.*, 1883, or in my paper, *Phil. Mag.*, 1884, was used, and that with complete success. In the experiments about to be described, this was replaced by a rotating commutator which had been fitted up by Prof. Thomson and Mr. Searle for their experiments on the other value of v, and which possesses certain advantages over the other form. Dr. Muirhead and Dr. Fleming have also used a

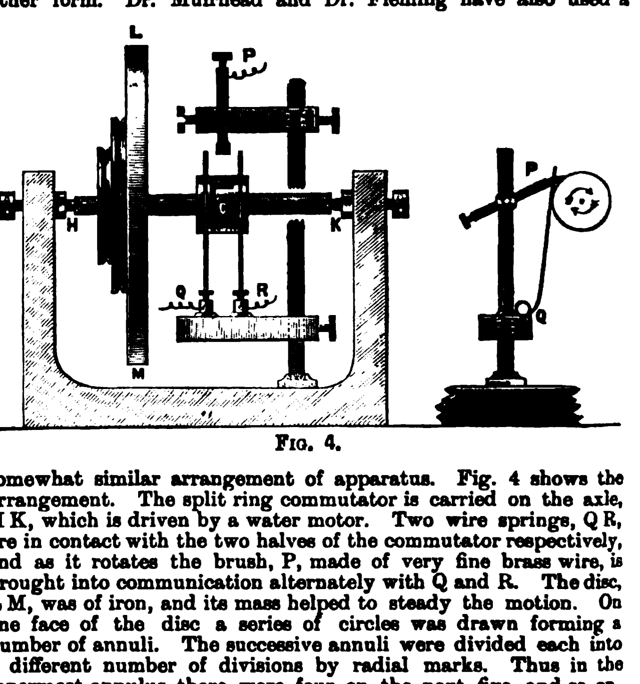


FIG. 4.

somewhat similar arrangement of apparatus. Fig. 4 shows the arrangement. The split ring commutator is carried on the axle, H K, which is driven by a water motor. Two wire springs, Q R, are in contact with the two halves of the commutator respectively, and as it rotates the brush, P, made of very fine brass wire, is brought into communication alternately with Q and R. The disc, L M, was of iron, and its mass helped to steady the motion. On one face of the disc a series of circles was drawn forming a number of annuli. The successive annuli were divided each into a different number of divisions by radial marks. Thus in the innermost annulus there were four, on the next five, and so on. The disc, as it rotated, was watched in the usual stroboscopic

Surely figures of this kind must appeal to those shareholders who have subscribed this large amount of capital, and who would, immediately their tramways were worked electrically, earn this extra dividend; and if tramway directors are slow of themselves in adopting this successful and economical method of propelling their tramcars, it should be the duty of the shareholders in their own interests to stimulate them to its adoption.

There are, roughly, three methods in which electric tramways may be operated electrically: 1. With conductors supported overhead on poles or wires, as with the line in the exhibition. 2. Conductors laid under the road surface in a conduit. 3. Without conductors at all, the energy being derived from accumulators carried within the car itself.

The first two systems derive their energy at all points of the line from a generating station containing the boilers, engines, and dynamos, or, if there should be water power in the neighbourhood of the tramway, from turbines and dynamos, and these must be kept constantly running as long as the tramcars are in motion. In the third method there is a generating station as before, but the current generated therein, instead of being conveyed direct to the cars by conductors radiating from the station, it is utilised for the charging of batteries of accumulators which are carried by the cars; and the cars, therefore, are not dependent for their motion upon the continuous running of the machinery in the generating station. This, coupled with the fact that the cars can run on any line without alteration to the track—assuming it is strong enough to bear the weight—constitutes the advantage of this system, which, however, cannot at all compare in cost of maintenance with the direct conductor method, and, therefore, will not be dealt with in this paper.

The first method with conductors suspended overhead is the method adopted by an overwhelming large percentage of the electrical tramways in existence. A bare conductor of silicium bronze is suspended overhead, either directly from a bracket attached to a post, if the track runs by the side of the road, or from a cross suspension wire stretched between two posts on either side of the road if the track runs in the centre of the road. This conductor of silicium bronze is insulated from the bracket, or from the cross suspension wire, by means of an insulator composed almost entirely of mica, and much stronger and better adapted for the work than an ordinary porcelain insulator.

The size of this bare conductor, or trolley wire, as it is more usually termed, may be any size from No. 6 to No. 2 S.W.G.; and if the length of the tramway and the number of cars running upon it is such that the conductivity of the larger size wire would be too small, another insulated cable is run along the posts supporting the brackets or suspension wires, and tapped at intervals into the bare conductor or trolley wire to reduce its total resistance.

Where turn-outs or crossings occur, points and crossings—of much the same description as those used on the tramway lines underneath—are provided, but, of course, are inverted.

The current is collected from the trolley wire by means of a long, light, and strong swivelling arm mounted on the car roof, at the end of which is either a small wheel or a sliding shoe. The wheel or shoe is kept pressed against the bare conductor overhead by a spring or weight at the other end of the swivelling arm, and this method of maintaining contact with the overhead conductor leaves nothing to be desired in practice. It matters hardly at all how rough the track may be, the collecting shoe remains pressed against the conductor with a pertinacity that is quite phenomenal, and it hardly ever leaves the trolley wire.

The silicium bronze trolley wire being of a very hard nature, and the rubbing surface of the contact shoe or contact wheel being soft, the trolley wire itself hardly wears at all, all the wear being on the sliding shoe or wheel, and these are provided with renewable tyres, which cost but little, and, indeed, the total cost of the wear and tear between an overhead conductor and the sliding shoe or wheel is so little that it is hardly calculatable per car mile run.

The city of Boston is supposed to be one of the finest architecturally in the United States, and at the present moment the whole of the tramways of the city of Boston—one of the largest tramway systems in any one town of the world—is being fitted up with overhead conductors. Surely, if there is no objection in a large city like this to the use of overhead conductors under these conditions, in this country there must be numerous opportunities, at least in smaller towns and country lines, for utilising the same simple and efficient method of conducting the current to electric tramcars.

No doubt it requires but the introduction of a few such lines substantially erected to overcome the prejudice of local authorities to the use of overhead conductors.

In the larger towns, however, there is no likelihood of the authorities ever permitting the use of overhead conductors, and then the choice is limited to the use of either the accumulator system or the second method mentioned—viz., conductors laid under the road surface. We do not believe that with the present large depreciation upon accumulator cells this method will find favour with most tramway conductors, and that, therefore, the underground system is destined to be that ultimately used in our larger cities.

Of late there have been advocated several systems in which a closed conduit is used containing a conductor insulated from the earth and brought temporarily into contact with a surface rail divided into sections, as the car passes over these sections. This plan has not, however, been yet brought into operation on any practical scale, and we believe that although such a system might be made to work on a small scale under favourable conditions, it is improbable that with the very unfavourable electrical conditions of an ordinary road, this system could be relied upon for constant satisfactory working.

In the other or open conduit system two methods of constructing the conduit itself, as apart from the electrical fittings it contains, may be used. The first consists of building a conduit between the two track rails and having upon the surface of the road a slot formed by two rails laid flush with the pavement, and introducing an extra amount of metal in the road, which more is more or less objectionable to the local authorities. In March of last year, however, an electrical tramway at Northfleet was opened, in which for the first time the conduit was built underneath one of the running rails, the car wheels on one side travelling on one of the rails forming the slot of the conduit itself. This method of construction meets the objections of the local authorities, as it does not in any way add to the amount of metal placed upon the road surface.

Of open conduit systems with continuous conductors several have been tried without success. The objection to those tried so far, however, has been that the conductor is buried in the conduit, and cannot be got at without ripping open the conduit itself, and, as the size of the conduit must necessarily be small to keep the cost of construction to as low a figure as possible, very imperfect insulators are provided for supporting the conductors within the conduit, and these cannot be got at with facility for cleaning purposes. As a result the insulation is very imperfect and considerable leakage of current usually follows, and any repairs to the conductor necessitates a stoppage of the tramway and a taking up of the road.

To ensure an absolutely reliable open conduit system it is essential (1) that all the electrical fittings should be so designed that they can be placed in position or removed for the purposes of renewal without disturbing the road surface, and they must at all times be easy of access; (2) to ensure good insulation the supports should be as infrequent as possible, and where requisite they should be insulated from the rail by means of efficient insulators; (3) rigid collecting arms should be employed to ensure absolute accuracy of travel, to prevent any risk of contact being broken, and to dispense with points and crossings on the conductor; (4) all the devices used, either electrical or mechanical, must be very simple and cheap.

What is now known as the Waller-Manville system of conduits has been designed with a view to embody all these important considerations. In this system is employed a flexible conductor sufficiently small to admit of its being placed in or withdrawn through the slot. The conductor being flexible, the supports can be at long intervals, such as 30ft., and can therefore be placed in side openings to the conduit and not in the conduit itself. By this means space is provided for large and efficient insulators. Removable covers are provided to these side openings, or hatchways, giving ready access to the insulators. The insulators are mounted in such a manner that on removing the cover they can be at once lifted out.

The collecting arm is so designed that the shank can be withdrawn through the slot and the collector proper through any hatchway.

Under ordinary conditions the conductor simply rests on supporting arms without being attached thereto. When it is necessary to firmly attach the conductor to its support, as, for instance, on sharp curves, absolute flexibility is still maintained, as the supports are so designed that, whilst rigidly resisting either a longitudinal or lateral strain, the same freedom of upward movement is allowed, as in the case of the conductor itself when unattached.

Simple automatic apparatus is provided at intervals to maintain a constant strain upon the conductor, and to prevent sagging too much between the supports.

The current is collected by means of a U-shaped collector, or shoe in which the conductor runs, the collector lifting the conductor off the ordinary supports during its travel, and in the case of the supports to which the conductor is attached lifting the support itself.

The conductor rests upon the collecting shoe, which passes clear of the supporting arm from the insulator, allowing the conductor when it has passed to fall back again upon the supporting insulator. This method of collection is similar to that which has been described as having proved extremely efficient with the overhead system.

An automatic tension apparatus is so designed that whilst maintaining a constant tension upon the conductor no extra strain or weight is put upon the collecting arm as it passes beneath the apparatus.

It will be seen, then, that whilst all the conditions which are met with in a tramway are fulfilled, the apparatus employed to fulfil these conditions never interferes with the upward flexible movement of the conductor upon which the perfect contact thus obtained depends; also, that no nuts or bolts, or other means of permanently attaching the insulators and their supports to the conduit, are used. Each insulator with its support is complete in itself, and can be removed from the hatchway instantly for cleaning purposes or renewal. The conductor requires the minimum of work to place it in position, as it is but necessary to drop it through the slot along the road to fasten it to the compensating devices and curve devices, and then the mere action of the collecting shoe passing under the conductor the first time places it in position on the supports along the straight parts of the line.

One of the difficulties hitherto encountered with conduit tramways is that of keeping the conduit itself clear of dirt and road *débris* owing to the obstruction caused by the electrical fittings to the passage of a brush or cleaning device. It will readily be seen that this difficulty does not exist in this system, there

being no obstruction to the passage of a brush attached to a car which will sweep the dirt into receptacles provided at the hatchboxes, from whence it can readily be removed.

Before concluding this paper we would describe to you the method used on the exhibition tram line for attaching the motors to the tramcars and gearing their armatures up to the car wheels. The same method is used whether the current be supplied from overhead conductors or from underground conductors on a very large percentage of the electrical tram lines now in operation, and experience has proved it to be a very satisfactory method indeed.

The field magnets of the motor are supported in a cradle of gun-metal, which also supports the bearings for the armature and for the countershaft. One end of this cradle terminates in an eye running over a stud supported on a beam carried across the bottom of the car truck, and a flange round the eye rests upon a strong spring; the other end of the cradle terminates in two plummer blocks, which rest directly upon one of the axles of the truck.

The armature is geared to the countershaft by a cast-steel double helical pinion and wheel, and the other end of the countershaft is geared to the car axle by a similar pinion and wheel.

By thus only attaching the motor at one end of the car axle, and allowing it to move to a certain degree radially round the car axle, by supporting at the other end in the way described, great flexibility is obtained, and the effect of the vibrations caused by the wheels travelling over the track and communicated to the motor are thus minimised as far as possible.

Those who are interested in this method of mounting the motor can inspect the arrangement on one of the cars in the grounds, and also any of the other details referred to in this paper.

We have endeavoured to describe to you, in perhaps an imperfect manner, besides the system of telpherage, the methods of working electrical tramways through overhead conductors or underground conductors in an open conduit. The subject is one of pressing interest at the present time, and is worthy of treatment at far greater length than is possible within the limits of this paper; and this must be our excuse for making the descriptions as short as possible, and not entering into many details which in themselves are important.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

LECTURE I.

(Concluded from page 320.)

TRACTION METHODS.

Another group of methods of measuring permeability is based upon the law of magnetic traction. Of these there are several varieties.

(D) Divided Ring Method.—Mr. Shelford Bidwell has kindly lent me the apparatus with which he carried out this method. It consists of a ring of very soft charcoal iron rod 6·4 millimetres in thickness, the external diameter being 8 centimetres, sawn into two half rings, and then each half carefully wound over with an exciting coil of insulated copper wire of 1,929 convolutions in total. The two halves fit neatly together; and in this position it constitutes practically a continuous ring. When an exciting current is passed round the coils both halves become magnetised and attract one another. The force required to pull them asunder is then measured. According to the law of traction, which will occupy us in the second lecture, the tractive force (over a given area of contact) is proportional to the square of the number of magnetic lines that pass from one surface to the other through the contact joint. Hence the force of traction may be used to determine B; and on calculating H as before, we can determine the permeability. The following Table IV. gives a summary of Mr. Bidwell's results.

TABLE IV.—(Square Centimetre Measure).

Soft Charcoal Iron.

B	μ	H
7,390	[illegible]	3·9
11,550	1121·4	[illegible]
15,460	386·4	40
17,330	150·7	115
18,470	[illegible]	206
19,330	45·3	[illegible]
19,820	33·9	585

(E) Divided Rod Method.—In this method, also used by Mr. Bidwell, an iron rod hooked at both ends was divided across the middle, and placed within a vertical surrounding magnetising coil. One hook was hung up to an overhead support; to the lower hook was hung a scale-pan. Currents of gradually increasing strength were sent around the magnetising coil from a battery of cells, and note was taken of the greatest weight which could in each case be placed in the scale-pan without tearing asunder the ends of the rods.

(F) Permeameter Method.—This is a method which I have myself devised for the purpose of testing specimens of iron. It is essentially a workshop method, as distinguished from a laboratory method. It requires no ballistic galvanometer, and the iron does not need to be forged into a ring or wound with a coil. For carrying it out a simple instrument is needed, which I venture to denominate as a permeameter. Outwardly it has a general resemblance to Dr. Hopkinson's apparatus, and consists, as you see (Fig. 19), of a rectangular piece of soft wrought iron, slotted out to receive a magnetising coil, down the axis of which passes a brass tube. The block is 12in. long, 6½in. wide, and 3in. in thickness. At one end the block is bored to receive the sample of iron to be tested. This consists simply of a thin rod about a foot long, one end of which must be carefully surfaced up. When it is placed inside the magnetising coil, and the exciting current is turned on, the rod sticks tightly at its lower end to the surface of the iron block; and the force required to detach it (or, rather, the square root of that force) is a measure of the permeation of the magnetic lines through its end-face. In the first permeameter which I constructed the magnetising coil is 13·64 centimetres in length, and has 371 turns of wire. One ampere of exciting current consequently produces a magnetising force of H = 34. The wire is thick enough to carry 30 amperes, so that it is easy to reach a magnetising force of 1,000. The current I now turn on is 25 amperes. The two rods here are of "charcoal iron" and "best iron" respectively; they are of ¼in. square stuff. Here is a spring balance graduated carefully, and provided with an automatic catch so that its index stops at the highest reading. The tractive force of the charcoal iron is about 12¼lb., while that of the "best" iron is only 7¼lb. B is about 19,000 in the charcoal iron, and H being 850, μ is about 22·3. The law of traction which I use in calculating B will occupy us much in the next lecture, but meantime I content myself in stating it here for use with the permeameter. The formula for

FIG. 19.—The Permeameter.

calculating B when the core is thus detached by a pull of P pounds, the area of contact being A square inches, is as follows:

$$B = 1{,}317 \times \sqrt{P \div A} + H.$$

I may add that the instrument in its final form is manufactured from my designs by Messrs. Nalder Bros., the well-known makers of so many electrical instruments.

CURVES OF MAGNETISATION AND PERMEABILITY.

In reviewing the results obtained, it will be noted that the curves of magnetisation all possess the same general features, all tending toward a practical maximum, which, however, is different for different materials. Joule expressed the opinion that "no force of current could give an attraction equal to 200lb. per square inch," the greatest he actually attained being only 175lb. per square inch. Rowland was of opinion that the limit was about 177lb. per square inch for an ordinary good quality of iron, even with infinitely great exciting power. This would correspond roughly to a limiting value of B of about 17,500 lines to the square centimetre. This value has, however, been often surpassed. Bidwell obtained 19,820, or possibly a trifle more, as in Bidwell's calculation the value of H has been needlessly discounted. Hopkinson gives 18,250 for wrought iron, and 19,840 for mild Whitworth steel. Kapp gives 16,740 for wrought iron, 20,460 for charcoal iron in sheet, and 23,250 for charcoal iron in wire. Bosanquet found the highest value in the middle bit of a long bar to run up in one specimen to 21,428, in another to 29,388, in a third to 27,688. Ewing, working with extraordinary magnetic power, forced up the value of B in Lowmoor iron to 31,560 (when μ came down to 3), and subsequently to 45,350. This last figure corresponds to a traction exceeding 1,000lb. to the square inch.

Cast iron falls far below these figures. Hopkinson, using a magnetising force of 240, found the values of B to be 10,78[illegible] in grey cast iron, 12,408 in malleable cast iron, and 10,546 in mottled cast iron. Ewing with a magnetising force nearly 50 times as great, forced up the value of B in cast iron to 31,760. Mitis metal, which is a sort of cast wrought iron, being a wrought iron rendered fluid by addition of a small percentage of aluminium, is, as I have

* Cantor lectures, delivered before the Society of Arts.

short space of time. If, for example, the motor was on the truck as well as the body of the car, and the removal of the armature was desired, it would only require the opening

Fig. 1.—Westinghouse Electric Railway Motor.

of the bottom of the car, and the unhinging of the field magnets. The armature could then be taken out in a few seconds. To make this process of removing the armature still more easy, the company manufactures a small portable

Fig. 2.—Westinghouse Electric Railway Motor—Plan of Motor and Truck.

hoisting device, which fits into the oil pockets of the frame, and enables one man to remove any part of the motor.

The construction of the field coils has been very carefully conducted. Indeed, the experience which the Westinghouse Company has gained in winding and insulating high-tension apparatus proves here to be of the utmost advantage, and it has been exercised in making the coils waterproof. They can easily be changed by slipping them over the magnet cores, and they are held immovable by brass rings.

The durability of any motor depends chiefly upon the construction of the armature. In the Westinghouse motor the shaft is made very heavy, is constructed of steel, and

the armature is built up to prevent any loosening of its details. The armature shaft is of varying diameter, being thicker in the centre and tapering towards each end.

The commutator is constructed of a special composition metal made by the company, and is insulated so as to prevent burning out. All the details of the commutator are held together rigidly, and are fastened to the armature shaft in a manner which obviates jarring or breaking of the armature wires.

The brush-holder bracket is fastened rigidly to the frame, and a wooden bar carries the brush-holder arms. This method has been adopted to prevent vibration or shifting of the brushes.

The gears in the motor are heavier than ordinarily employed. The face of the gear wheel is wider, to give more wearing service.

The armature pinion and the countershaft pinion are made of steel. The axle wheel and the countershaft wheel, however, are of cast iron. The armature pinion, the countershaft pinion, and the wheels are all bored taper fashion and their shafts are turned correspondingly. These parts are keyed together. A powerful spring is used behind two nuts to keep the wheels in place. The advantage of this method will be readily appreciated by those who realise that there is considerable heating in the pinions, which expand more than the shafts and thus become loose. The purpose of this taper hole and shaft is that should the pinion expand more than the shaft, the spring will force the pinion tighter on the shaft, and the loss of any motion between the latter and the wheel will be obviated.

All motor parts are held together by through-going bolts, and spring washers are utilised to prevent the loosening of the nuts on account of constant jarring and shaking. The motor is supported upon the truck by two springs, which diminish the strain on the crossbeams. In Fig. 1 the gear wheels are not shown. They are surrounded by an iron box which is used principally to deaden the noise caused by wheels. The box surrounding the gears is filled with a peculiar lubricating material which reduces the friction of the gears and renders their movements, it is stated, practically noiseless, while adding at the same time to their durability.

Fig. 2 gives a plan view of the truck.

To prevent accumulation of dust in the several parts of the motor, a sheet-iron pan has been placed beneath the bottom of the motor and a sailcloth curtain surrounds the side of the apparatus. The ordinary overhead trolley wire system is used in connection with the motor.

In Pittsburg, Pa., the motors have now been operated on the streets since July 3, and they have become extremely popular in that city.

In Lansing, Mich., the operation of the motors is declared successful in every particular. The company has now contracts for 50 roads, and the equipment for them is being turned out at the Pittsburg and Newark works as rapidly as the capacity of the shops permits.—*Western Electrician.*

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

Lecture II.

GENERAL PRINCIPLES OF DESIGN AND CONSTRUCTION.—PRINCIPLE OF THE MAGNETIC CIRCUIT.

(*Continued from page 368.*)

Here let me go to a matter which has been one of the paradoxes of the past. In spite of Joule, and of the laws of traction, showing that the pull is proportional to the area, you have this anomaly—that if you take a bar magnet having flat-ended poles, and measure the pull which its pole can exert on a perfectly flat armature, and then deliberately spoil the truth of the contact surface, rounding it off, so making the surface gently convex, the convex pole, which only touches at a portion of its area instead of over the whole, will be found to exert a bigger pull than the perfectly flat one. It has been shown by various experimenters, particularly by Nicklès, that if you want to increase the pull of a magnet with armatures, you may reduce the polar surface. Old steel magnets were frequently purposely made with a rounded contact surface. There are plenty of examples. Suppose you take a straight round core, or one leg of a horseshoe, which answers equally, and take a flat-ended rod of iron of same diameter as an armature; stick it on endwise, and measure the pull when a given amount of ampere-turns of current is circulating round. Then, having measured the pull, remove it and file it a little, so as to reduce it at the edges, or take a slightly narrower piece of iron, so that it will actually be exerting its power over a smaller area, you will get a greater pull. What is the explanation of this extraordinary fact? A fact it is, and I will show it to you. Here, Fig. 24, is a small electromagnet which we can place with its poles upwards. This was very carefully made, the iron poles very nicely faced, and on coming to try them it was found they were nearly equal, but one pole, A, was a little stronger than the other. We have, therefore, rounded the other pole, B, a little; and here I will take a piece of iron, C, which has itself been slightly rounded at one end, though it is flat at the other. I now turn on the current to the electromagnet, and I take a spring balance, so that we can measure the pull at either of the two poles. When I pull the flat end of C to the flat pole, A, so that there is an excellent contact, I find the pull about 2¼lb. Now try the round end of C on the flat pole, A; the pull is about 3lb. The flat end of C on the round pole, B, is also about 3lb. But if now I put together two surfaces that are both rounded, I get almost exactly the same pull as at first with the two flat surfaces. I have made many experiments on this, and so have others. Take the following case: There is hung up a horseshoe magnet, one pole being slightly convex and the other absolutely flattened, and there is put at the bottom, on a square bar armature, over which is slipped a hook to which weights can be hung. Which end of the armature do you think will be detached first?

If you were going simply by the square inches, you would say this square end will stick on tighter; it has more gripping surface. But as a matter of fact, the other sticks tighter. Why? We are dealing here with a magnetic circuit. There is a certain total magnetic reluctance all round it, and the whole number of magnetic lines generated in the circuit depends on two things—on the magnetising force, and on the reluctance all round; and, saving a little

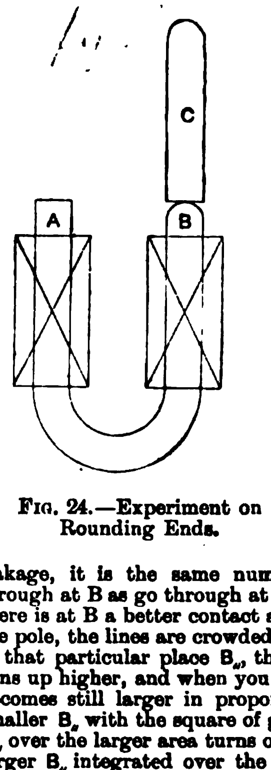


FIG. 24.—Experiment on Rounding Ends.

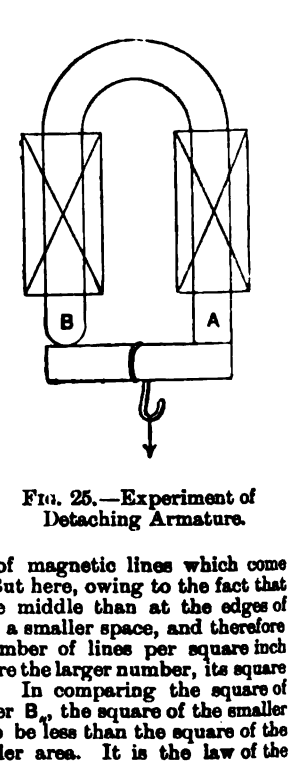


FIG. 25.—Experiment of Detaching Armature.

leakage, it is the same number of magnetic lines which come through at B as go through at A. But here, owing to the fact that there is at B a better contact at the middle than at the edges of the pole, the lines are crowded into a smaller space, and therefore at that particular place B'', the number of lines per square inch runs up higher, and when you square the larger number, its square becomes still larger in proportion. In comparing the square of smaller B' with the square of greater B'', the square of the smaller B'' over the larger area turns out to be less than the square of the larger B'' integrated over the smaller area. It is the law of the square coming in.

As an example, take the case of a magnet pole formed on the end of a piece of round iron 1·15in. in diameter. The flat pole will have 1·05in. area. Suppose the magnetising forces are such as to make $B'' = 90,300$, then, by Table VI., the whole pull will be 118·75lb., and the actual number of lines through the contact surface will be $N = 948,158$. Now suppose the pole be reduced by rounding off the edge till the effective contact area is reduced to 0·9 square inches. If all these lines were crowded through that area that would give a rate of 105,630 per square inch. Suppose, however, that the additional reluctance and the leakage reduced the number by 2 per cent., there would still be 103,500 per square inch. Reference to Table VI. shows that this gives a pull of 147·7lb. per square inch, which, multiplied by the reduced area, 0·9, gives a total pull of 132·9lb., which is larger than the original pull.

Let me show you yet another experiment. This is the same electromagnet, Fig. 24, which has one flat pole and one rounded pole. Here is an armature, also bent, having one flat and one rounded pole. If I put flat to flat and round to round, and pull at the middle, the flat to flat detaches first; but if we take round to flat, and flat to round, we shall probably find they are about equally good—it is hard to say which holds the stronger.

The law of traction can again be applied to test the so-called distribution of free magnetism on the surface. This is a subject on which I shall have to say a good deal. We must therefore

* Cantor lectures, delivered before the Society of Arts.

carefully consider what is meant by the phrase. Let Fig. 26 be a rough drawing of an ordinary bar magnet. Everyone knows that if we dip such a magnet into iron filings the small bits of iron stick on more especially at the ends, but not exclusively, and if you hold it under a piece of paper or cardboard and sprinkle iron filings on the paper, you obtain curves like those shown on the diagram. They attest the distribution of the magnetic forces in the external space. The magnetism running internally through the body of the iron begins to leak out sideways, and finally all the rest leaks out in a great tuft at the end. These magnetic lines pass round to the other end, and there go in again. The place where the steel is internally most highly magnetised is this place across the middle, where externally no iron filings at all stick to it. Now, we have to think of magnetism from the inside and not the outside. The magnetism extends in lines, coming up to the surface somewhere near the ends of the bar, and the filings stick on wherever the magnetism comes up to the surface. They do not stick on at the middle part of the bar, where the metal is really most completely permeated through and through by the magnetism; there are a larger number of lines per square centimetre of cross-section in the middle region where none come up to the surface, and no filings stick on. Now, we may explore the leakage of magnetic lines at various points of the surface of the magnet by the method of traction. We can thereby arrive at a kind of measure of the amount of magnetism that is leaking; or, if you like to call it so, of the intensity of the "free magnetism" at the surface. I do not like to have to use these ancient terms, because they suggest the ancient notion that magnetism was a fluid, or, rather, two fluids; one of which was plastered on at one end of the magnet, and the other at the other; just as you might put red paint or blue paint over the ends. I only use that term because it is already more or less familiar. Here is one of the ways of experimentally exploring the so-called distribution of free magnetism. The method was, I believe, originally due to Plücker; at any rate it was much used by him. This little piece of apparatus was arranged by my friend and predecessor, Prof. Ayrton, for the purpose of teaching his students at the Finsbury College. Here is a bar magnet of steel, marked in centimetres from end to end; over the top of it there is a little steelyard, consisting of a weight

FIG. 26.—Lines of Force running through Bar Magnet.

sliding along an arm. At the end of that steelyard there is suspended a small bullet of iron. If we bring that bullet into contact with the bar magnet anywhere near the end, and equilibrate the pull by sliding the counterpoise along the steelyard arm, we shall obtain the definite pull required to detach that piece of iron. The pull will be proportional, by Maxwell's rule, to the square of the number of magnetic lines coming up from the bar into it. Shift the magnet on a whole centimetre, and attach the bullet a little further on; now equilibrate it, and we shall find it will require a rather smaller force to detach it. Try it again at points along from the end to the middle. The greatest force required to detach it will be found at the extreme corner, and a little less a little way on, and so on until we find at the middle the bullet does not stick on at all, simply because there are here no magnetic lines leaking. The method is not perfect, because it obviously depends on the magnetic properties of the little bullet, and whether much or little saturated with magnetism. Moreover, the presence of the bullet perturbs the very thing that is to be measured. Leakage into air is one thing, leakage into air perturbed by the presence of the little bullet of iron, which invites leakage into itself, is another thing. It is an imperfect experiment at the best, but a very instructive one. This method has been used again and again in various cases for exploring the apparent magnetism on the surface. I shall use it hereafter, reserving the right to interpret the result by the light of the law of traction.

I now pass to the consideration of the attraction of a magnet on a piece of iron at a distance. And here I come to a very delicate and complicated question. What is the law of force of a magnet, or electromagnet, acting at a point some distance away from it? I have a very great controversy to wage against the common way of regarding this. The usual thing that is proper to say is that it all depends on the law of inverse squares. Now, the law of inverse squares is one of those detestable things needing to be abolished, which, although it may be true in abstract mathematics, is absolutely inapplicable with respect to electromagnets. The only use, in fact, of the law of inverse squares, with respect to electromagnetism, is to enable you to write an answer when you want to pass an academical examination set by some fossil examiner who learned it years ago at the university, and never tried an experiment in his life to see if it was applicable to an electromagnet. In academical examinations they always expect you to give the law of inverse squares. What is the law of inverse squares? We had better understand what it is before we condemn it. It is a statement to the following effect: that the action of the magnet (or of the pole, some people say) at a point at a distance away from it varies inversely as the square of the distance from the pole. There is a certain action at one inch away. Double the distance; the square of that will be four, and inversely the action will be $\frac{1}{4}$; at double the distance the action is $\frac{1}{4}$; at three times the distance the action is $\frac{1}{9}$, and so on. You just try it with any electromagnet; nay, take any magnet you like, and unless you hit upon the particular case, I believe you will find it to be universally untrue. Experiment does not prove it. Coulomb, who was supposed to establish the law of inverse squares by means of the torsion balance, was working with long thin needles of specially hard steel, carefully magnetised so that the only leakage of magnetism from the magnet might be as nearly as possible leakage in radiating tufts at the very ends. He practically had point poles. When the only surface magnetism is at the end faces, the magnetic lines leak out like rays from a centre, in radial lines. Now the law of inverse squares is never true except for the action of points; it is a point law. If you could get an electromagnet or a magnet, with poles so small in proportion to its length that you can consider the end face of it as the only place through which magnetic lines leak up into the air, and the ends themselves so small as to be relatively mere points; if, also, you can regard those end faces as something so far away from whatever they are going to act upon that the distance between them shall be large compared with their size, and the end itself so small as to be a point, then, and then only, is the law of inverse squares true. It is a law of the action of points. What do we find with electromagnets? We are dealing with pieces of iron which are not infinitely long with respect to their cross-section, and generally possessing round or square end faces of definite magnitude, which

FIG. 27.—Apparatus to Illustrate the Law of Inverse Squares.

FIG. 28.—Deflection of Needle.

are quite close to the armature, and which are not so infinitely far away that you can consider the polar face a point as compared with its distance away from the object upon which it is to act. Moreover, with real electromagnets there is always lateral leakage. The magnetic lines do not all emerge from the iron through the end face. Therefore, the law of inverse squares is not applicable to that case. What do we mean by a pole, in the first place? We must settle that before we can even begin to apply any law of inverse squares. When leakage occurs all over a great region, as shown in this diagram, every portion of the region is polar. The word polar simply means that you have a place somewhere on the surface of the magnet where filings will stick on, and if filings will stick on to a considerable way down toward the middle, all that region must be considered polar, though more strongly at some parts than at others. There are some cases where you can say that the polar distribution is such that the magnetism leaking through the surface acts as if there were a magnetic centre of gravity a little way down, not actually at the end; but cases where you can say there is such a distribution as to have a magnetic centre of gravity are strictly few. When Gauss had to make up his magnetic measurements of the earth, to describe the earth's magnetism, he found it absolutely impossible to assign any definite centre of gravity to the observed distribution of magnetism over the northern regions of the earth; that, indeed, there was not in this sense any definite magnetic pole to the earth at all. Nor is there to our magnets. There is a polar region, but not a pole; and if there is no centre of gravity of the surface magnetism that you can call a pole from which to measure distance, how about the law of inverse squares? Allow me to show you an apparatus, Fig. 27, the only one I ever heard of, in which the law of inverse squares is true. Here is a very long, thin magnet of steel, about 3ft. long, very carefully magnetised so as to have no leakage until quite close up to the end. The consequence is that for practical purposes you may treat this as a magnet having point poles, about an inch away from the ends. The south pole is upwards, and the north pole is below, resting in a groove in a base-board which is graduated with a scale, and is set in a direction east and west. I use a long magnet and keep the south pole

well away, so that it shall not perturb the action of the north pole, which, being small, I ask to be allowed to consider as a point. I am going to consider this point as acting on a small compass needle suspended over a card under this glass case constituting a little magnetometer. If this were properly arranged in a room free from all other magnets, and set so that the needle shall point north, what will be the effect of having the north pole of the long magnet at some distance eastwards? It will repel the north end and attract the south, producing a certain deflection which we can read off; reckoning the force which causes it by calculating the tangent of the angle of the deflection. Now, let us move the north pole (regarded as a point) nearer or farther, and study the effect. Suppose we halve the distance from the pole to the indicating needle, the deflecting force at half the distance is four times as great the force at double the distance is one quarter as great.

Fig. 29.—Closed Magnetic Circuit.

Wherefore? Because, firstly, we have taken a case where the distance apart is very great compared with the size of the pole; secondly, the pole is practically concentrated at a point; thirdly, there is only one pole acting; and, fourthly, this magnet is of hard steel, and its magnetism in no way depends on the thing it is acting on, but is constant. I have carefully made such arrangements that the other pole shall be in the axis of rotation, so that its action on the needle shall have no horizontal component. The apparatus is so arranged that whatever the position of that north pole, the south pole, which merely slides perpendicularly up and down on a guide, is vertically over the needle, and, therefore, does not tend to turn it round in any direction whatever. With this apparatus one can approximately verify the law of inverse squares. But this is not like any electromagnet ever used for any useful purpose. You do not make electromagnets long and thin, with point poles a very large distance away from the place where they are to act. No, you use them with large surfaces close up to their armature.

Fig. 30.—Divided Magnetic Circuit.

There is yet another case which follows a law that is not a law of inverse squares. Suppose you take a bar magnet, not too long, and approach it broadside-on towards a small compass needle, Fig. 28. Of course, you know as soon as you get anywhere near the compass needle it turns round. Did you ever try whether the effect is inversely proportional to the square of the distance reckoned from the middle of the compass needle to the middle of the magnet? Do you think that the deflections will vary inversely with the squares of the distances? You will find they do not. When you place the bar magnet like that, broadside-on to the needle, the deflections vary as the cube of the distance, not the square.

Now, in the case of an electromagnet pulling at its armature at a distance, it is utterly impossible to state the law in that misleading way. The pull of the electromagnet on its armature is not proportional to the distance, nor to the square of the distance, nor to the cube, nor to the fourth power, nor to the square root, nor to the three-halfth root, nor to any other power of the distance whatever, direct or inverse, because you find, as a matter of fact, that as the distance alters something else alters too. If your poles were always of the same strength, if they did not act on one another, if they were not affected by the distance in between, then some such law might be stated. If we could always say, as we used to say in the old language, "at that pole," or "at that point," there are to be considered so many "units of magnetism," and at that other place so many units, and those are going to act on one another; then you could, if you wished, calculate the force by the law of inverse squares. But that does not correspond to anything in fact, because the poles are not points, and, further, the quantity of magnetism on them is not a fixed quantity. As soon as the iron armature is brought near the pole of the electromagnet there is a mutual interaction; more magnetic lines flow out from the pole than before, because it is easier for magnetic lines to flow through iron than through air. Let us consider a little more narrowly that which happens when a layer of air is introduced into the magnetic circuit of an electromagnet. Here we have, Fig. 29, a closed magnetic circuit, a ring of iron, uncut, such as that on which we experimented last week. The only reluctance in the path of the magnetic lines is that of the iron, and this reluctance we know to be small. Compare Fig. 29 with Fig. 30, which represents a divided ring with air gaps in between the severed ends. Now, air is a less permeable medium for magnetic lines than iron is, or, in other words, it offers a greater magnetic reluctance. The magnetic permeability of iron varies, as we know, both with its quality and with the degree of magnetic saturation.

(To be continued.)

A COMPARISON OF A PLATINUM THERMOMETER WITH SOME MERCURY THERMOMETERS AT LOW TEMPERATURES.*

BY E. H. GRIFFITHS, M.A., SIDNEY COLLEGE, CAMBRIDGE.

The paper describes the mode of constructing an air-tight platinum thermometer for use at low temperatures. The thermometer was graduated by means of the freezing and boiling points of water, and as regards intermediate points Regnault's determinations of the temperature and pressure of aqueous vapour were adopted. The precautions observed in the construction of the apparatus, and in the method of observation, are described. The thermometer was tested by comparison with a number of thermometers standardised at Kew. The curves, showing the result of these determinations, are in remarkably close agreement, and when the observations were sufficiently numerous it appeared possible to calibrate the bore as accurately as by the usual more laborious process. The further advantage of this method is that thermometers can be compared under the conditions in which they are to be used.

In a communication to the Royal Society read on June 19th, 1890, I described a method of constructing and graduating platinum thermometers and gave a table of boiling and freezing points for various substances lying between 100deg. and 500deg., determined by means of these instruments.

Subsequent observations indicate that a slight change appears to be taking place in the readings of these thermometers. I attribute this (1) to alterations in the glass, (2) to presence of moisture in the tube—the asbestos roll on which the spiral was wound being highly hygroscopic. I therefore decided to construct a thermometer in which there should be no contact between the glass and the platinum, and which should be thoroughly dry and hermetically sealed.

I was unable to discover any suitable non-conductor capable of resisting high temperatures; but in anthracene (melting point 213deg.) I found a substance suitable in every respect for use at low temperatures. I subjected a sample to severe tests and, up to a temperature of about 130deg., found it to be a better insulator than paraffin.

The leads to the coil were constructed of silver, the inner one a rod and the outer a tube. The resistance of these leads was about ·001 ohm, and, therefore, any change in the external resistance, caused by change of temperature, might be disregarded. The silver leads approached to within about 1in. of the spiral, and were connected to it by moderately thick platinum wires; thus a flow of heat from the spiral to the silver was diminished. The wire forming the coil was about 56in. in length, and had a diameter of ·005in. The spiral was about 2in. long, having a resistance of about 13·5 ohms at 0deg. C., and the external diameter of the covering tube was about ·3in. The ends of the asbestos roll were made of greater diameter than the portion on which the spiral was wound, and thus there was no glass contact. The tube and contents were heated up to a temperature of several hundred degrees and dried air passed through it for some hours. It was then exhausted and the open end placed under the surface of melted anthracene, which was allowed to rise until nearly in contact with the coil. When cool, the whole of the thermometer, from the spiral to the upper end (about 13in.), was a solid mass, while the spiral and asbestos roll were perfectly dry and in an

* Paper read before the British Association.

almost vacuous space. I have taken nearly 600 observations with this thermometer and cannot detect any signs of change. When the lower part was undergoing rapid changes in temperature, thermo-electric effects showed themselves, but by reversing the battery and galvanometer connections during each reading these effects were eliminated. A low-resistance galvanometer was used, and the current, which passed through the thermometer when determining its resistance, did not exceed one-hundredth ampere. To illustrate the closeness of the agreement in the results obtained at different times I give the following determinations of the resistance at 100deg. taken in the usual manner by means of a hypsometer with manometer attached. Full corrections were made in the barometric reading, and the results reduced to lat. 45deg.

Date.		Temperature. Deg. C.	Resistance (after corr. for temp. of coils).
July	26	100	18·2029
,,	27	100	18·2034
August	12	100	18·2025
,,	13	100	18·2031
		Mean ...	[illegible]

The expression for the platinum temperature by this thermometer was

$$\frac{R - 13 \cdot 5219}{4 \cdot 6811} \times 100, \text{ again } \frac{R_{100}}{R_o} = 1 \cdot 3462,$$

almost exactly agreeing with the coefficient of the wire in Mr. Callendar's air thermometer (*Phil. Trans.* A. 1887).

Mr. G. M. Clark, B.A. (Sidney Coll., Cambridge), now joined me in the investigation, and as we proposed to use this thermometer for the calibration and graduation of mercury thermometers between 0deg. and 100deg., we decided to obtain intermediate temperatures by means of Regnault's numbers connecting the temperature and pressure of aqueous vapour. For this purpose we constructed a large iron tank with two plate glass sides, holding about 16 gallons of water, and through two holes bored in the bottom, inserted two barometer tubes, the upper 16in. of each being within the tank. One of these was used as a standard barometer, and was prepared with great care, the distilled mercury, with which it was filled, having been boiled in the tube for more than six hours. The internal diameter of the tube was 14 mm., and the absence of any meniscus was very marked. If the level of the surface of the water in the tank was below the top of the barometer, and the water warmed, the sublimation of mercury in the vacuous space was observable. The second barometer was made from the same length of tubing as the first, and communicated at its upper extremity with a small flask, A, in which was placed the platinum thermometer.

Charts A, B, C, D, and E.

Distilled water was boiled in vacuo for some hours, to expel all traces of air. The flask and barometer tube were then exhausted by means of an air pump, and the lower end of the tube placed in a flask, B, containing the previously boiled water, which rushed up, filling the tube and flask A.

The water remaining in B was then boiled until this flask and a bent tube passing from it into a bason of mercury, 30in. beneath, were completely filled with steam, and, on cooling, the height of mercury in the tube enabled us to determine that the pressure on its surface was that of aqueous vapour only. The water in the upper flask was then boiled for many hours, and only allowed to cool occasionally to permit of the water in the lower flask being boiled away. To prevent access of air, the steam was driven off through the mercury. When the water in flask A was reduced to about a tablespoonful, the boiling was stopped, and the

level of the mercury was raised until it flowed back first into flask B, and thence into the barometer tube, as flask A cooled.

The open end of the barometer tube was then sealed, the flask B replaced by a small cup of dry mercury, and the end of the tube opened below the surface. The water remaining on the top of the column was driven back into the flask by pouring hot water over the tube.

During our experiments, water occasionally collected on the mercury, but by means of a concave mirror it was driven back into the flask; the mirror was of course removed some time before an observation was taken.

The tank, filled with water, was maintained at any required temperature by means of a gas regulator. The lower parts of the barometer tubes were screened by sheets of asbestos, and the two cups were connected by a small syphon. The glass sides of the tank were covered with white paper to prevent radiation, openings were left for observations, during which the water in the tank was kept in a continual state of agitation by the oscillation of a large paddle driven by a water motor. The paddle, fixed in one corner of the lid, swept across the tank driving the water before it and lifting it at the same time. We have tried several forms of stirrers, and we believe this to be a more effective form than a screw or a plunger.

The difference in the height of the mercury in the two barometer tubes was ascertained by the kathetometer G. 33, in the Cavendish Laboratory, and by means of it readings could be taken to ·50 mm. Care was taken to bring both levels horizontal before each observation.

As the coefficient of expansion of the kathetometer scale was unknown, and the temperature of the room usually about 20deg. C., we decided to compare it with the standard scale R, whose coefficient of expansion and scale errors had been determined by the Standards Department of the Board of Trade.*

Twenty-one comparisons were made (greatest divergence from the mean ·10 mm.), and the result was as follows: 300·35 mm. on kathetometer scale at 20deg. (=300·35489) of Board of Trade standard (S.S.) at 0deg.

Thus no scale correction was necessary.

The difference (D) of the mercury columns was corrected for temperature pressure of mercury vapour and latitude, and the resulting length denoted by D_0: the temperature corresponding to D_0 was deduced from the very full table given in Part 3 of Carnelly's "Melting and Boiling Point Tables."

The extremities of the curve at (0deg. and 100deg.) having been determined, it was only necessary to get points between 30deg. and 80deg.

Ninety observations were taken, and although occasional divergences presented themselves, the mean path gives a curve which we believe to be within less than ·02deg. of the true path at all points. It agrees closely with the curve obtained by Mr. Callendar from the parabola $1{\cdot}57\left[\left(\frac{t}{100}\right)^2-\frac{t}{100}\right]$, by measuring one-tenth of the ordinate along the abscissa.†

The following equation, however, represents its path more accurately:

$y = {\cdot}018795\,t - {\cdot}0001991\,t^2 + {\cdot}000{,}000{,}111{\cdot}5\,t^3$. The curve itself is shown in Chart A.

We proceeded to test our conclusions by comparison with thermometers standardised at Kew. For this purpose a rotating annular ring, through the centre of which the platinum thermometer passed, was inserted in the lid of the tank in such a manner that the mercury thermometers, fixed in holes bored near its circumference, could successively be brought into the field of view of the kathetometer without any readjustment of the telescope; the thermometers were then read by one observer whilst the platinum resistances were taken by the other. The freezing points were not, however, determined by this method, but by direct immersion in powdered ice, adopting the precautions recommended by Guillaume in his Thermometrie de Précision.

The following curves were then drawn, which indicate the result of the comparison of our platinum thermometer with those standardised at Kew.

Curve.	Thermometer. Kew No.	Standardised.
B	75148	October, 1888.
C	75149	October, 1888.
D	43762	May, 1865.
E	8394	Dec., 1880; Jan., 1882; April, 1888.

All these thermometers were made by Hicks, the first three were kindly placed at our disposal by Mr. R. T. Glazebrook, the last is one of those referred to by Mr. W. N. Shaw in a communication to the B.A. during the Bath session, the successive curves of which, then exhibited by him, he has kindly allowed us to copy.

In these diagrams the abscissæ represent the temperature, in the strong curves, that obtained by us, and in the faint, that obtained by Kew; the ordinates in each case being the divergence of the actual readings from these results. Where crosses occur at almost identical temperatures they indicate observations separated by a considerable interval of time—in no case did less than 20 minutes elapse, whilst in others several days.

Three only of our observations are unrecorded on these charts, and in each case, owing to imperfect light, interruptions, etc., these experiments were regarded as doubtful before their results were deduced.

The gradual rise of the zero point is clearly indicated; apparent discrepancies are probably due to the fact that the Kew determinations are less frequent than ours, and as a consequence many of the smaller deviations have escaped notice.

The results show:

1. That thermometers whose range does not include 0deg. and 100deg., may have certain fixed points determined by this method.

2. That an actual calibration of a mercury thermometer can also be readily accomplished.

3. That the platinum thermometer, properly constructed, may serve as a standard by which to trace the changes which may take place in mercury thermometers.

4. That since the readings of the platinum thermometer are independent of the extent of the stem-immersion, it can be conveniently employed for the graduation of thermometers partially immersed, as in ordinary use.

During the past few days we have calibrated about 20 thermometers by this method, and we believe the results to be satisfactory in all cases.

* Standard metre, verified June, 1882, designated R in Mr. Chaney's report.

† It must be remembered that Callendar's difference curves gives the connection between platinum and air-thermometer temperatures, whilst Regnault used a mercury thermometer (M.A.S. XXI.), and thus curve A gives the relation between platinum and mercury thermometer temperatures.

SECONDARY CELLS.*

BY W. J. S. BARBER STARKEY.

I shall only try to give a few of my personal experiences with secondary cells without attempting to go into their theory or construction, and I do this more in the hope that it may lead to some interesting discussion, than for any value which may be attached to my experiences. Soon after the introduction of M. Faure's cells into this country I was fortunate enough to become possessed of one, which for a time gave excellent results, but it so happened I had to go away from home for six months, and on my return I found the cell would no longer work satisfactorily, and had become very inefficient.

To find out the cause of this I removed the plates from their felt envelopes, and found that they were partially covered with a white hard sulphate of lead, which I was unable again to reduce. I also found that it had eaten into the supporting plates, and that there was a thin film of white sulphate between these plates and the active material, which practically acted as a non-conductor. This seemed to me such a serious defect that I determined if possible to find out a remedy, and, after numberless ineffectual attempts, I at last found out that if a small quantity of carbonate of soda was added to the dilute acid, it not only allowed the existing sulphate to be again reduced, but it also prevented the formation in future of the hard white intractable sulphate, even if the cells were allowed to stand idle for any length of time. I have allowed plates to remain idle in this solution for more than 18 months without the slightest trace of white sulphate appearing. Five years ago next Christmas, a small installation consisting of 22 E.P.S. 350 ampere-hour cells was fitted up for me, and it so happened that the dilute acid was, by mistake, put into the accumulators a considerable time before the engine was ready to run, by which time the plates showed signs of sulphating, and as I had only a small current of 10 amperes at my disposal, I was not able again to bring the plates to their proper state, and the sulphating became worse and worse, till all the plates presented a dull grey appearance. I showed them to several electrical experts, and the opinion was that they were ruined, and the only suggestion was that I should pass a heavy current for a long time through the cells. This I was unable to do with the power at my disposal, but I passed a current of 10 amperes continuously through them for a week without the slightest apparent results. Seeing this treatment

* Paper read before the British Association.

was hopeless, I then determined to try the carbonate of soda which I had used on a small scale some years previously on the Faure cell. I was told that I should probably ruin the cell, so I began cautiously. Into one cell out of the 22 I put a small quantity of carbonate of soda (ordinary washing soda), and I then went on charging as before, and before many hours had elapsed I was delighted to see that the plates in the cell, to which carbonate of soda had been added, were beginning to assume their proper appearance, the positive plates becoming a very dark brown peroxide, and the negative plates a clear metallic lead, which was a great contrast to the uniform dull grey appearance of all the plates in the other cells. As soon as I was convinced that the treatment with carbonate of soda was satisfactory, I added it to all the other cells, with the result that in a short time every trace of the formerly intractable white sulphate disappeared, and the cells presented a beautiful appearance. It is now nearly five years since the cells were thus treated, and they have never shown signs of sulphating, and are apparently in as good condition now as when new. I was so much impressed with the use of carbonate of soda to prevent sulphating of the plates that I brought the matter before Mr. Preece, and he very kindly came to look at the cells, and afterwards carried out a most careful series of experiments to determine the value or otherwise of using sulphate of soda in secondary cells. The results of these experiments are, I believe, well known, and have been published, and the exact amount of carbonate of soda which it is desirable to use has been determined; it is only necessary to use a very small quantity to effect the desired purpose. If much is used it is of no advantage, and may tend to cause scaling of the plates. Now that is no longer necessary to pass a heavy current through cells to prevent sulphating, it appears to me that it would be much more satisfactory to use larger cells for stationary work, and both charge and discharge them at a considerably lower rate than at present recommended, thereby enormously increasing the life and efficiency of the cells, and leaving a large surplus of energy in case of emergency. My own cells have been treated in this way, and I cannot see that they have in any way deteriorated after nearly five years' use. If the plates are kept free from sulphate they may be bent to a considerable extent without suffering any damage, and if the grids are made of pure soft lead they may be readily straightened again. Certainly, my experience leads me to recommend the use of soft lead grids in preference to those of a hard and brittle alloy. I consider that burning the lugs together is the most satisfactory way of connecting up the cells, but if brass screws and nuts are used they can be greatly protected by pressing some lead foil over and around them; this will keep off any acid spray which might reach them while the cells are being charged, and should any of the brass connections become corroded I have found that they can be effectually cleaned without trouble by immersing them for a time in a solution of carbonate of soda, and then washing them thoroughly in pure water. If it is desired to use separators between the plates, a very simple and cheap way to make them is to use perforated porous paper which has been saturated in melted paraffin wax; this stands well in dilute acid, and I have some which have been in use for several years.

Although secondary batteries are now undoubtedly very efficient when carefully used for stationary purposes, it appears to me that as at present constructed they will not stand for any long period the wear and tear, shaking and washing of the liquid against the active material to which they must be subjected when used for traction purposes; at least, such is the impression left on my mind after inspecting cells which have been used for even a short time; some of the plates generally soon show signs of buckling, and the bottom of the cells became covered with disintegrated particles of the active material, which forms a sort of mud. I have endeavoured to overcome these defects by packing the plates in a solid though porous mass of plaster of Paris mixed with sawdust, and for three months a battery of 96 cells thus prepared was successfully running a tramcar at Canning Town and doing the same work as the other cars. However, at the end of this time the management passed into other hands, and I hear that the cells have been taken to pieces, as they were not giving satisfaction, so for the present this experiment has come to an end, and is apparently a failure, but I have not given up hopes that some modification of this plan may be successful, as for a time the working was very satisfactory. The proportion of plaster of Paris used in this experiment was two of plaster of Paris to one of sawdust, but I think the plaster of Paris was not pure, and its proportion was too great. I am now using a set of 22 Elwell-Parker cells, in which the proportion is two and a half of sawdust to one of plaster of Paris. The way I prepare the cells is to mix the plaster of Paris and sawdust intimately together in a dry state, and fill in the spaces between the plates with this mixture. I then pour in gently some dilute sulphuric acid to which a little carbonate of soda has been added, when the whole sets into a compact porous mass. After a time I pour in the electrolyte till it stands above the level of the tops of the plates, and it will be found that the cells will contain nearly as much liquid as if no porous material were used.

Last autumn I used a set of these cells in conjunction with a turbine and dynamo, and although they were last charged in November, I found on my return this year in June that they still retained the charge well after seven months' rest, and burnt the lamps brightly, the E.M.F. of each cell being just under two volts. Although in my experiments I have used plaster of Paris to insulate the particles of sawdust from each other, and to give stability to the porous mass, I have tried many other substances, both soluble and insoluble, mixed with it, but sawdust appears to act as well as anything which I have yet tried, and it has the advantage of being cheap, and easily procurable. This method of treating the cells would appear to be of no advantage in stationary work for electric lighting purposes, and would indeed be a distinct disadvantage, as owing to the want of free circulation of the liquid, the E.M.F falls more rapidly under a long-continued heavy discharge, but it immediately recovers with a short interval of rest, and, in practice, these intervals are constantly occurring in electric traction, when the car stops to take up and set down passengers, and with cells treated in this way the vibration and shaking of the car is a positive advantage, as it facilitates the circulation of the electrolyte, and tends to liberate any occluded gases. The defect of this arrangement would appear to be that it must hinder the free circulation of the liquid and also add to the internal resistance of the cell, whilst, on the other hand, it prevents the plates from buckling, retains the active material firmly in its place, preserves the plates from injury, and makes the cell very portable. I have ventured to mention this crude experiment in the hope that it may induce someone to produce a thoroughly practical cell for traction purposes which will stand rough usage and be free from the defects which at present exist.

As regards the use of carbonate of soda in secondary cells, a case has just been brought to my notice which appears worthy of mention. I am told that at the Central News office, Ludgate-hill, 28L 13 cells had been lying dry and idle for upwards of two years, and each plate was encrusted with hard white sulphate; with ordinary dilute sulphuric acid and a charging current of 10 to 15 amperes no difference was seen after two charges of eight hours per day; after adding about half a pint of strong carbonate of soda solution to the dilute sulphuric acid in the cells and doing the same electrical work as before, the plates were observed to change colour in a few hours, and in a few days each of the cells presented a beautiful appearance, not a single plate buckled, and I am told that the battery is working perfectly now. This entirely confirms my experience. After plates have been brought to a good condition by the use of carbonate of soda, the ordinary dilute sulphuric acid may be substituted for the mixed electrolyte if the cells are to be used for continuous work; but I believe a small amount of sodium salt is always beneficial. It, however, only becomes a necessity where cells have to stand idle for long periods.

COMPANIES' REPORTS.

WESTMINSTER ELECTRIC SUPPLY CORPORATION, LIMITED.

Report of the Board of Directors to the ordinary general meeting of shareholders, to be held on Wednesday, Nov. 5, 1890.

Directors: The Right Honourable Lord Suffield, K.C.B., Edmund Boulnois, Esq., M.P., W. Hayes Fisher, Esq., M.P., Sir Douglas Galton, K.C.B., F.R.S., M.I.E.E., J. Browne Martin, Esq., James Heslop Powell, Esq., Roger W. Wallace, Esq. General Manager: Captain Edmund I. Bax. Engineer-in-Chief: Prof. Alex. B. W. Kennedy, F.R.S., M.I.C.E. Secretary: Frank Iago, Esq.

In making their report to the shareholders the Board are pleased to be able to state that the affairs of the Corporation are proceeding in a rapid and satisfactory manner. The first work which claimed their attention after the allotment of the shares was that of obtaining suitable sites for central stations, three of which were required for the supply of the district which had been allotted to the Corporation. In January last the Board acquired the undertaking of the City of Westminster Electrical Syndicate, Limited, who had commenced business in the district, and thereby obtained possession of St. John's Wharf, Millbank-street, and also of the contract for electric lighting in the Houses of Parliament. After considerable trouble and delay, the Board succeeded in obtaining two other eligible sites, one in Eccleston-place, Belgravia, and the other in Davies-street, Mayfair, both being on the Duke of Westminster's estate. Pending the installation of the large central stations, current has been supplied from two temporary stations, one in the stoneyard adjacent to the Houses of Parliament, and the other in Dacre-street, Victoria-street. By means of these temporary stations the nucleus of a good business has been formed, and at the present time current is being supplied from underground mains equivalent to about 6,000 eight-c.p. lamps on circuit. The demand for current already far exceeds the amount which can be generated from the plant in actual work, but the new station at St. John's Wharf is now running, and able to take over the work in the Westminster district, and allow the Dacre-street plant to supply as far as Belgrave-square, pending the completion of the Eccleston-place station. The installations in Mayfair and Belgravia are rapidly advancing. The mains have been laid in many of the principal streets, and are being laid as quickly as possible in the others, and the Board hope that current will be supplied from both these stations early in the new year. The Board have ordered plant—viz., engines, boilers, dynamos, batteries, etc.—to the amount of about 2,600 i.h.p. for the three stations, a large part of which has already been delivered. This will be sufficient to supply about 40,000 8-c.p. lamps alight at one time, allowing an ample margin for steam power in reserve. According to present experience this will correspond to upwards of 100,000 8-c.p. lamps on circuit. The system of distribution adopted is the low-tension continuous current. The mains already laid are shown on maps, which can be seen at the Corporation's offices, and amount in all to nearly 11 miles, and permission has already been obtained from the authorities for the whole system of proposed mains. The financial year ends on December 31, and the accounts

will be made up and audited to that date, and the Board recommend that in future the annual general meeting of the shareholders should be held in the month of February, when the accounts would be ready for presentation.

NEW COMPANIES REGISTERED.

British Insulated Wire Company, Limited.—Registered by T. T. Hull, 22, Chancery-lane, W.C., with a capital of £60,000, in £5 shares. Object: to purchase or otherwise acquire any patents, brevets d'invention, licenses, concessions, and the like, conferring an exclusive or non-exclusive or limited right to use any inventions capable of being used in the manufacture of wire and wire ropes and cables, or any other invention which may seem to the Company capable of being profitably dealt with. The first subscribers are:

	Shares.
J. B. Atherton, Mayfield, Huyton, Lancashire	1
J. Atherton, Eldon House, Huyton, Lancashire	1
T. P. Hewitt, Eccleston Park, Prescot	1
S. H. Hartley, Eccleston Park, Prescot	1
W. M. Brigg, Hawkestone, Keighley	1
J. H. Dodd, 53, North John-street, Liverpool	1
J. Beckett, Longview, Huyton	1

There shall not be less than three nor more than seven Directors; the first to be appointed by the subscribers to the memorandum of association. Qualification not specified. Remuneration, £200, and 10 per cent. of net profits after 10 per cent. dividend.

British and Foreign Patents Purchase and Development Company, Limited.—Registered by Henry Green, Bedford-row-chambers, W.C., with a capital of £2,000 in £1 shares. Object: to purchase British, foreign, and colonial patents. Most of the articles of Table A apply.

Electro-Chemical Syndicate, Limited.—Registered with a capital of £5,000 in £1 shares.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the past week amounted to £4,834.

Electrical Engineering Corporation.—Mr. Carl von Buch, of Messrs. Foote and Von Buch, 11, Queen Victoria-street, has joined the Board.

South of England Telephone Company.—The Directors have declared a dividend at the rate of 6 per cent. per annum on the preference shares for the half-year ending 31st inst.

Indo-European Telegraph Company.—The Directors have declared an interim dividend for the half-year ended June 30 at the rate of 5 per cent. per annum, tax free, payable on Nov. 1.

Western and Brazilian Telegraph Company, Limited.—The traffic receipts of this Company for the past week after deducting the fifth payable to the London Platino-Brazilian Company, were £3,742.

Montevideo Telephone Company, Limited.—The report of the Directors for the year ending July 31 last shows a gross profit of £10,301. Off this sum there has been written £114 for preliminary expenses, etc., leaving £10,167, and making, with the balance from last year, a total of £10,492. The Directors recommend the full dividend of 6 per cent. on the preference shares, also that £1,000 be added to the depreciation fund, and that the balance, £1,184, be carried forward.

PROVISIONAL PATENTS, 1890.

October 20.

16631. **A switch for interchanging constant current dynamos without breaking the continuity of the circuit on to which they are to work.** George Septimus Hooker, Glen View, Oldfield Park, Bath.

16653. **Improvements in apparatus for measuring the strength of electric currents.** Stanley Charles Cuthbert Currie, 323, High Holborn, London. (Complete specification.)

16675. **Improvements in water motors and in dynamo machines to be driven by same.** Wilhelm Charles Fischer, 55, Chancery-lane, London.

October 21.

16717. **Improvements in electrically signalling in mines and in apparatus therefor.** William Cairns and Alexander Ferrie Mabon, 62, St. Vincent-street, Glasgow.

16747. **Improvements in the manufacture of electrical insulating materials.** James Raper Thame, 17, Godolphin-road, Shepherd's Bush, London.

16752. **Improvements in electrical switches.** Thomas Reginald Andrews and Thomas Preece, Sunbridge-chambers, Bradford.

16792. **An improved arrangement of regulating device for electric arc lamps.** Albert de Puyat, 45, Southampton-buildings, London.

October 22.

16809. **Improvements in electric blank heating and feeding apparatus for forging machines.** George Dexter Burton, 52, Chancery-lane, London. (Complete specification.)

16811. **The improvement of switchboards for the regulation and control of electrical currents.** Percival Gerard Pochin, 13, Ranmoor-park, Sheffield.

16835. **An improved electrical conductor for fitting in mine shafts and underground haulage roads for electrical signalling purposes.** Wm. Cairns and Alexander Ferrie Mabon, 10, West Campbell-street, Glasgow.

16837. **Improvements in the manufacture, construction, and building up of secondary battery elements, electrodes, or plates.** Jerrold E. Douglass, 37, Wilmington-square, London.

16844. **An improvement in the construction of accumulators or secondary batteries.** Henry Weymersch, 10, Moorgate-street, London.

16847. **An improved electric switch.** William Lownds, Elliott Emanuel, and Joseph Wood, Fairlawn Park, Chiswick.

October 23.

16889. **Improvements in electromotors.** Rankin Kennedy, 10, India-street, Kilmarnock. (Complete specification.)

16934. **A new electric battery.** Michel Azapis, 55, Chancery-lane, London.

16958. **A method of and apparatus for signalling by means of electricity.** John Annan Bryce, Norfolk House, Norfolk-street, London.

October 24.

16963. **Improved means of placing conductors for electricity underground.** Wilson Hartnell, 8, Blenheim-terrace, Leeds.

17018. **Improved joints or connectors for uniting wires or cables, temporarily or otherwise, for electrical or other purposes.** William Bishop, 69, Oakfield-roud, Stroud Green, London.

October 25.

17035. **Improvements in electricity meters.** John Lea, 5, Aberdeen-terrace, St. James' End, Northampton.

17062. **Improved electric switch.** John Pitt Bayly, 18, Fulham-place, Paddington, London. (Charles Herrick, United States.)

17063. **An improved electric lampholder and switch combined.** John Pitt Bayly, 18, Fulham-place, Paddington, London. (Charles Herrick, United States.)

17108. **Improvements in dynamo-electric machines.** George Pitt, 24, Southampton-buildings, London. (René Thury, Switzerland.)

SPECIFICATIONS PUBLISHED.

1889.

15963. **Electrodes for electrical batteries.** Schoop. 6d.

17205. **Obtaining zinc by electrolysis.** Elmore. 4d.

17521. **Distribution, etc., of electric currents.** Clark (Schuckert and Co.). 11d.

17581. **Regulating, etc., electric currents.** Joel. 8d.

17652. **Electric arc lamps.** Rider. 6d.

18028. **Electric accumulators.** De Pass (Société Jacquet Frères.) 8d.

18526. **Transmitting telegraphic signals.** Lake (Field). 8d.

1890.

941. **Electric tramways and tramcars.** Lineff and Bayley. (Reprints with alterations.) 11d.

3169. **Electro-heating apparatus.** Carpenter. 8d.

9780. **Electric railway signals.** Smith and Fox. 8d.

11456. **Phonographs.** Magenis and Richmond. 8d.

11669. **Phonographs, etc.** W. S. G. and W. S. G. Elliott. 1s 1d.

12532. **Electric arc lighting.** Pitt (Sautter, Harlé and Co.). 8d.

13635. **Electric welding.** Thompson (Coffin). 6d.

13636. **Electric welding.** Thompson (Coffin). 6d.

13802. **Electrical measuring instruments.** Walker. 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2½
Swan United	3¾	5½
Crompton & Co., Pref.	—	5¼
National Telephone	5	5¼
Electric Construction	10	8

NOTES.

St. Saviour's Board of Works.—The Board have consented to the Brush Company applying for a provisional order.

Aluminium from Clay.—Mr. J. M. Hirsch, of Chicago, says he is now turning out over 300lb. of aluminium (from clay) per diem.

Book Received.—"Electric Light, its Production and Use," fourth edition, revised and with additions, by J. W. Urquhart (Crosby Lockwood and Son).

Award.—A gold medal has been awarded to Messrs. Lacombe and Co. for their carbon exhibit in the French electrical section of the late Edinburgh Exhibition.

Electro-Harmonic Society.—We may remind our readers that a capital programme awaits them at the smoking concert in the banquet-room of St. James's Hall at eight this evening.

Heywood (Lancs.).—The Town Council will not consent to applications for orders by Messrs. Latimer Clark, Muirhead, and Co., and the Electric Construction and Maintenance Company.

Gas Engines.—"Don't place your pressure bags below the floor" is the moral to be deduced from an explosion which took place last week at the Edinburgh Exhibition, with the result of causing a small fire.

Electric Lighting for Collieries.—It is said that the Fife Coal Company have arranged for the introduction of the electric light into their pits at Leven, the lamps to be placed 15 yards apart along the roads.

Electrical Omnibuses.—Mr. Radcliffe Ward hopes to have his buses running early in the new year, in spite of the delays and difficulties to which the company have been put in the matter of obtaining a site for their depot.

New Ship.—The "Amra," built by the Ailsa Shipbuilding Company, of Troon, for the British India Steam Navigation Company, has just run her trials, with the result of attaining a mean speed of 12·8 knots. She is lighted electrically.

Sweden and Telephony.—The Swedish Telephone Management has devoted 1,600 kronen towards the expenses of sending an expert to visit Holland, England, and America with the view of ascertaining the latest improvements made there in telephony.

Bury (Lancs.).—A committee of the Town Council is making enquiries as to what demand there is for electric lights in the compulsory area. They are to report as to the advisability or otherwise of the Council executing the necessary works for supplying electric light.

Frankfort-on-Main Exhibition.—A congress is to be held in connection with this exhibition, and Herr Werner Siemens will be asked to occupy the presidential chair. Herr Von Stephan, of Berlin, has accepted the chairmanship of the Organising Committee of the exhibition.

The Chemical Union.—This long-talked-of union of chemical manufacturers has been registered under the title of the United Alkali Company, Limited. Some particulars, from which it will be seen that the new concern is of an omnium-gatherum nature, will be found in another column.

Edinburgh.—A sub-committee of the Lord Provost's Committee of the Edinburgh Town Council, have agreed upon the compulsory area of the city for the purposes of electric lighting, and adjusted the necessary parliamentary notices in connection with the application for a provisional order.

Electric Tramway between Lytham and Blackpool.—A proposal is now on foot to construct an electric tramway from Lytham to Blackpool. The subject has been under consideration by the General Purposes Committee of Blackpool Corporation; and details have also been furnished to the Lytham Commissioners.

Ireland.—The Ennis Gas Consumers' Company have been prosecuted for substituting smaller burners on five of the public lamps than were contracted for, thereby reducing the light afforded. Verily town authorities seem to be waking up and insisting on having the whole light and nothing but the light they contracted for.

The Cable to the Azores. — A telegram to the *Morning Post*, dated Lisbon Tuesday, says: "It is reported that the Government have decided not to authorise the laying of a telegraph cable to the Azores, although they have been invested with the power by Parliament to lay down telegraph communication with these islands."

Personal.—Mr. Magnus Volk having completed the fitting out of the fleet of electric launches on the River Thames, belonging to the General Electric Power and Traction Co. (late Messrs. Immisch and Co.), his connection with the company has terminated, and he is devoting his attention to some new types of electrical measuring instruments.

New Steamer.—A new steamer for Messrs. Donald Currie and Co.'s intermediate or African service, the "Lismore Castle," was launched last week from Messrs. Barclay, Curle, and Co.'s yard at Whiteinch, Glasgow. She is 4,045 tons gross tonnage, and 410ft. in length, and is to be fitted with every modern appliance, including electric lighting.

Aberdeen.—The Gas Committee have raised gas 2d. per 1,000. Edinburgh and Dundee have also gone up 4d. and 3d. per 1,000 respectively. Aberdeen is going in for an order to supply electricity, and if gas continues to rise, there will soon be a feeling in favour of the healthier and pleasanter light which will not be without influence at the Town Council Board.

Hamburg and the Popp System.—Some time ago the Hamburg Senate sent a committee, in which were many distinguished mechanical and electrical engineers, to Paris to investigate the Popp compressed air system. The *Elektrotechnische Zeitschrift* learns that the report, which will shortly be circulated among members of the Senate, is an unfavourable one.

Stockholm.—The gas company have been granted permission by the authorities to proceed with the preliminary works necessary for the erection of the projected central station, although the detailed plans are not yet ready. It is said that the original estimate of 1½ million kronen will be too low, and that this amount will probably be increased to nearly two million kronen.

Eccleston-place Station.—The buildings for this station of the Westminster Electric Supply Company are progressing apace, and the smoke stack will soon be a prominent object in the neighbouring chimney-pot-scape. The general progress made by the company to date is outlined in our report of a meeting of the shareholders held on Wednesday, which will be found elsewhere.

Notes on Central Station Lighting.—This is the title of a paper read before the Liverpool Engineering

Society by Mr. C. H. Yeaman, A.I.E.E., and issued in the form of a pamphlet. A good deal of information is condensed into a small space, and there is no doubt papers of this kind read before the various societies by competent authorities are doing a vast amount of good.

Royal Institute of British Architects.—At the meeting of this institute on Monday last, the council-room was lit by electric light. An installation is being carried out here by the Planet Electrical Engineering Company, and for the evening a temporary connection was made with accumulators in the council-room. We understand that the light gave satisfaction to the members present.

A Naval Cable Vessel.—The *Globe's* naval correspondent says that it was for some time in contemplation to convert the "Hecla" into a sea-going telegraph ship, to carry some 2,000 miles of cable for use in time of war, but it is understood that to fit her for this duty would involve such a pulling to pieces and reconstruction as to make it more advisable to build a new ship for the purpose.

Institution of Electrical Engineers.—At the meeting on Thursday, November 13th, a paper will be read by Prof. Ayrton, and Messrs. C. G. Lamb, B.Sc., and E. W. Smith, "On the Chemistry of Secondary Cells." The above paper will be discussed together with that on "The Working Efficiency of Secondary Cells," by the same authors, which was read at the Edinburgh meeting on July 16th.

Lighting in Algeria.—The town of Mascara, Department Oran, proposes to use a waterfall about 30 kilometres distant, for lighting purposes. One hundred and eighty incandescents are to be used for the public lighting, and the theatre is also to be illuminated. Competitive schemes are invited and particulars can be had of the mayor of the town. The scheme also includes the distribution of water to the town.

Maidstone.—The town clerk has received notices under the Electric Lighting Act from the South of England House-to-House Electricity Company, Limited, Electric Installation and Maintenance Company, Limited, and the Municipal Electric Light and Power Corporation, Limited. The question of whether the local authority shall apply for an order themselves or not, has been referred to the Highways Committee.

St. Luke's (London, E.C.).—The Vestry of St. Luke's considered at their last meeting several applications from electric lighting companies for powers to lay their systems in the parish, and the Vestry resolved that application be made to the Corporation and other metropolitan authorities now supplied by the Brush Company, or under agreement with them for supply, for particulars of the terms agreed upon.

London Chamber of Commerce.—A meeting of the Electrical and Allied Trades Section will be held at the offices, Botolph House, Eastcheap, E.C., on Monday next at 4 p.m. Agenda: Board of Trade rules, proposals in regard to correspondent's duties, Mr. Crompton's scheme for the interchange of useful information, the approaching expiration of European commercial treaties, American tariff, and other matters.

Electricity in the French Navy.—It is stated that the French Minister of Marine has decided that every military port shall send to Paris two foremen and two working electricians to study the various systems of electric lighting. Lectures upon the theory and use of electricity and its employment for naval purposes will commence at the Paris Observatory on the 11th inst., and will be continued for four months.

Type Writers and Telegraphy.—Type-writing by telegraphy is now being practised in the United States on a short line in Rhode Island which will probably be extended to Boston this week, and in the opposite direction to New York by the beginning of next year. The operator's key-board at the transmitting office is electrically connected with any number of receiving offices, and the message is delivered from type-writing machines in these offices.

Ironclad Light Towers.—A committee appointed by the French Minister of War has been making trial of the new ironclad light towers destined for use in the fortresses along the banks of the Maas. The light will be supplied by a powerful arc lamp with fixed focus, and the feeding dynamo will be driven by a gas engine. The projectors and men working them are protected by steel armour. The cupola of the towers can be raised or lowered as circumstances require.

Alternative Cable to Australia.—Telegrams from Ottawa (Canada), under date Nov. 4, say that satisfaction is expressed there at the action of Lloyds in pressing upon Lord Salisbury and Mr. Goschen the importance of the alternative cable to Australia *viâ* the Pacific Ocean. While recognising that the advantages of this route are greater for England and Australia than for Canada, it is understood that the Dominion Government are prepared to liberally assist the scheme.

Significant.—In a paper on the excavation of the new Croton aqueduct, Mr. J. P. Carson, of New York, says: "For the first two years gasoline torches, miners' lamps, a few candles, and electric lights to some extent were used. The two former predominated. The air finally became so foul that an order was issued forbidding the use of torches or lamps, and after a time the torches were abandoned. In the construction of the masonry only candles and the electric light were employed."

Hanover.—Rules for the delivery of current from a central station have been drawn up. A footnote states that in all probability the regular delivery of current will begin on December 1st of this year. The monthly charge for hire of meters is as follows: For 15 incandescents of 16 c.p., or an equivalent current, 1·25 marks (not quite 1s. 3d.); for 60 incandescents, 2·25 marks; for 100 incandescents, 3 marks; for 200 incandescents, 4 marks; for 300 incandescents, 5 marks; for 400 incandescents, 6 marks; and for 600 incandescents, 7 marks, or a trifle less than 7s.

Harrogate.—As a result of the sub-committee's considerations, the Town Council have decided to apply for an order. Mr. Ellis, who moved the resolution to this effect, very sensibly advocated lighting the whole town so that the large hotels and private houses might have the chance of taking the light, and thus reduce the cost of production to the Corporation. So far as lighting the streets only was concerned, the scheme would be a financial failure, and the only way to make it pay was to sell it to private individuals, hotel keepers, tradesmen, and others. By the way, Harrogate has just got rid of the water-gas experimenters.

Ship Lighting.—The ss. "Francisco" was launched last Wednesday from the yard of Messrs. Robert Stephenson and Co., of Hebburn, for Messrs. Wilson, Sons, and Co., Hull. She is intended for the Atlantic trade, is 382ft. long, 46½ft. wide, and 30¼ft. deep. She is to be completely fitted with electric lights, and there are two systems for extinguishing fires on board, one by steam, the other by

apparatus supplied by the Automatic Fire Check Company, of London. Mr. R. Woodley, electrical engineer, of London, has carried out the lighting of several of Messrs. Wilson's steamers, and it is probable that he will light the "Francisco."

Fermoy.—At a meeting of the Town Commissioners held on Saturday last, Mr. Geo. B. Garvey, of Moneygall, King's County, Ireland, representative of the Electrical Engineering Corporation attended with respect to a proposition to light Fermoy with electricity. He said the project would not pay if the streets only were lit. It would require not less than 700 to 800 lights to make the cost approximate to that of gas. He asked for information as to the probable number of private consumers and a map of the town. The Commissioners promised to supply the information, and there is every probability that the matter will be finally decided before long.

Electric Lighting in Switzerland.—The Swiss *Building Times* gives the following statistics of the position of electric lighting and power transmission in that country at the end of 1889. There existed altogether 351 installations with 408 dynamos, of a total capacity of 5,150 kilowatts. These fed 51,155 incandescents of various candle-powers, and 845 arc lamps. Of these 351 installations, 347 used the direct current, and only four—viz., at Brunnen, Lucerne, and Vevey-Montreux, and Wald—used the alternate current. The motors were in 177 cases, or 50·4 per cent., hydraulic; in 138 cases = 39·3 per cent., steam engines; in 32 cases = 9·1 per cent., gas engines; and in four cases = 1·2 per cent., electromotors. Forty-one batteries of accumulators were used as reserves.

Electricity in Everyday Life.—This is the title of a natty little pamphlet by Mr. Frank B. Lea, B.A., A.I.E.E., which gives in a very concise and popular form reasons for adopting electricity for lighting and motive power, with descriptions of the apparatus used to produce and distribute it. Perhaps the chief feature of the compilation is the really excellent illustrations, which, beginning with the interior of electrically lighted houses, pass on to fittings, a central station, dynamos, search-lights on vessels, turbines driving dynamos, various uses of motors, launches, an electric crane, a telpher line, and electric tramcars showing overhead and storage systems of traction. A great many of these illustrations, which are capitally done, bear the signature "A. Snell." The price of the pamphlet is 2d., and we can recommend it to non-technical readers as a very understandable synopsis of the practical applications of electricity, almost every sentence being clearly illustrated by engravings. It is published by Mr. E. W. Allen, 4, Ave Maria-lane, E.C.

Telephony between London and Paris.—The work in connection with the establishment of telephonic communication between London and Paris is being pushed forward very rapidly on this side of the Channel, and has made such satisfactory progress during the last few weeks that it is stated communication will be established early in the new year, most probably as early as January. Some alterations, however, have been decided upon in reference to the route to be taken by the cable. Instead of crossing the Channel and touching the English coast near Hythe, it has been decided to land it at St. Margaret's Bay, where it will be connected with a special wire running from this point *viâ* Dover, Folkestone, Ashford, and Maidstone to London. More than one of the cables between England and France already land at St. Margaret's Bay, whence they are brought overland to Dover. The Post Office are going to purchase a site in the market square for the erection of an extensive and much more commodious pos and telegraph office.

Failure.—A meeting of the creditors of Walter Rowbotham, who had carried on the business of an electrical engineer at 27, Sidney-street, Salford, under the style of "Walter Rowbotham and Co.," was held at the offices of the Manchester Official Receiver, Bridge-street, on Tuesday. The statement of affairs showed liabilities to unsecured creditors of £2,079, and to partly secured creditors £700, or a total of £2,779. The assets disclosed amounted to £637, leaving a deficiency of £2,142. The debtor attributed his failure to falling off in the installation department of his business, non-delivery of goods, sickness, and want of capital. He made no offer, and the creditors authorised the Official Receiver to apply to the Court for an order of adjudication. Mr. T. Pilling, of Messrs. Trevor and Pilling, accountants, was appointed trustee with a committee of inspection.

The Junior Engineering Society.—On Friday afternoon last a very numerous party of members of this society visited the Royal Arsenal, Woolwich, by special facilities afforded through the kindness of Mr. W. Anderson, D.C.L., Director-General of Ordnance Factories, past-president of the society. The party divided at the entrance into sections, and proceeded through the laboratory, museum, gun factory, gun-carriage shops, saw mills, wood-working machinery department, engine and boiler houses, foundry, smithy, etc., in the course of which the visitors had excellent opportunities for closely observing the many interesting appliances and devices which are associated with the manufacture of ordnance. At the conclusion of the visit the expression of the thanks of the society was conveyed to Dr. Anderson for his kindness in connection with the occasion. The inaugural meeting of the society's tenth session takes place on the 21st inst., when Prof. S. P. Thompson, B.A., D.Sc., president-elect, delivers an address on "Electro-magnetic Mechanisms," which should prove very interesting.

Peterborough.—At the last meeting of the Town Council, Mr. Hunting moved that the Corporation should apply for a provisional order. He argued strongly in favour of the Corporation acquiring any monopoly of supplying electric light, and said he did not propose the resolution in any spirit of antagonism to the gas company. Three electric light companies had applied to the Board of Trade for provisional orders to supply the city with electricity, and if the Corporation did not move in the matter these companies would obtain the monopoly. The engineer had reported that an installation would cost £11,500. This was seconded. After some discussion, Councillor Herbert proposed an amendment to the effect that the Council considered it desirable to obtain powers for electric lighting, but having regard to the purchase of the Cattle Market and the Corporation's present financial position, the subject should be adjourned for a year. He thought that if such a resolution got on the books they would be able to take a better position with respect to the Board of Trade than they could if they let the matter lapse. This was carried.

Sulphate of Copper Battery.—M. Carré constructs a battery with a zinc cylinder placed in a glass jar filled with sulphate of zinc. The zinc rests on a wooden cross bar. The positive electrode is a copper tube filled with

sulphate of copper. It rests on a porcelain cup, which in turn is fitted to a vessel of parchment paper of the same diameter. A wooden tube placed at the top of the paper vessel allows the copper solution to flow automatically, its level gradually increasing with the working of the battery. The E.M.F. of a cell is about 1·07 volt. A large cell with a zinc 48 centimetres (18·90in.) long gives 15 to 25 amperes on short circuit; medium size with 24 centimetres zinc (9·4in.), eight to 12 amperes; and small size with 18 centimetres zinc (7in.) four to six amperes. A medium-sized cell experimented with at the Ecole de Physique, Paris, and discharged through a constant resistance gave a constant current of three amperes for 210 hours (eight days 18 hours). Its percentage of efficiency was 75 per cent. The E.M.F. was 1·06 volt, internal resistance ·1 ohm, useful energy 2·31 watts, total consumption of zinc 1,000 grammes, of sulphate of copper 4,730 grammes, or 1·58 grammes of zinc and 7·66 grammes of sulphate of copper per ampere-hour.

Shop Lighting in Newcastle-on-Tyne.—On Saturday night, Nov. 1st, Messrs. W. Newton and Co.'s very extensive bicycle, furniture, and piano showrooms and workshops were, for the first time, lighted throughout by the electric light. Messrs. Newton and Co. have several large and well-stocked suite-rooms for the display of furniture, and here 32-c.p., 50-c.p. and 100-c.p. lamps are used, fitted with highly ornamental floral glass shades. The lighting of one room is made particularly effective by means of skilfully disposed mirrors, in which is reflected an endless perspective of brilliant lights. In the upholsterers' workshops, packing-rooms, etc., the lamps are either protected by wire guards, or fitted with white enamelled iron shades, while in the piano department the same artistic floral shades are used as in the furniture-rooms. These shades have been made specially to Messrs. Newton's order, and are most satisfactory. In front of the building, overhanging Westgate-road, is fixed a 15-ampere Brockie-Pell arc lamp, suspended from a neat wrought-iron bracket. Altogether the installation is very satisfactory to the firm. The work has been carried out by Messrs. Sydney F. Walker and Co., of Newcastle and Cardiff, and current is supplied to the installation by the Newcastle and District Electric Lighting Company, Limited.

Chemically Pure Zinc.—According to *L'Electricien*, M. Cahaigne, of Paris, has succeeded in bringing the process of refining zinc by distillation within the limits of commercial requirements, and can deliver chemically pure metal, at a price higher than that of ordinary zinc, it is true, but, nevertheless, not excessively so. This zinc is more malleable than the ordinary metal, and is easily split into plates of great toughness by raising its temperature to 60deg. C. It may also be drawn with the greatest ease, and makes very useful battery rods. According to the tests made by M. L'Hôte, chemical expert, M. Cahaigne's zinc is not attacked in acid diluted to $\frac{1}{10}$th, and is free (at all events in proportions that can be analysed) from the metals and metalloids met with in commercial zinc, such as lead, tin, cadmium, copper, antimony, iron, silicium, sulphur, and arsenic. MM. Pouchard, Mathioux, and Co., electric clockmakers, have tried this zinc in the batteries which work their apparatus, and the results obtained are as follow: Cells containing carbon, zinc, and sal ammoniac were worked on a circuit of electric clocks, the time during which the current was furnished being about 90 hours. The consumption of pure zinc (not amalgamated) was 28 grammes per cell, whilst that of ordinary zinc, perfectly amalgamated, was 36 to 38 grammes. Moreover, the consumption of the former was very regular throughout its length, while ordinary zinc was consumed very irregularly, being pitted and almost wholly eaten through at the bottom of the liquid. With bichromate of potash batteries (with porous jars), using commercial sulphuric acid diluted to $\frac{1}{10}$th, a much more constant discharge was obtained than with ordinary zinc, and the rod could be left on open circuit in the porous jar without its being appreciably worn. The results obtained in the Ecole de Physique of Paris as to the resistance of the metal were as follow: Specific resistance at 0deg. C., 6·19 microhms-centimetre; temperature coefficient, 0·00354.

Edinburgh International Exhibition.—This exhibition, which was opened on May 1 last, was closed on Saturday evening. The total number of visitors to the exhibition has been 2,414,129. On Saturday night the number of persons admitted was 25,204. Darkness had set in before the electric light was turned on, and some of the exhibitors were using candles and gaslight at their stalls. It is said that the delay was caused through the non-payment of an account due to the electric light company. An arrangement was, however, come to, and the electric light was put on shortly before six o'clock. In the course of the evening Sir Thomas Clark, chairman of the executive council, addressed a crowded meeting in the Grand Hall. He said that that was the last day of the exhibition, which, notwithstanding its unfortunate financial position, had been a very great success, affording to the public an excellent means of instruction, entertainment, recreation, and amusement. During the last six months there had been gathered together the largest number of exhibitors from foreign countries that had ever assembled in Scotland; and the electrical section was one of the most wonderful displays of inventions that had ever been brought together at any exhibition. Mr. Bapty, the general manager, was carried shoulder high from the bandstand to the grand entrance by a number of students, who were followed by thousands of people. On arriving at the grand entrance, Mr. Bapty thanked the visitors for their attendance, and said he believed that if the financial state of the exhibition had been made known sooner, the public would have come to their assistance and prevented so large a deficiency. The doors were closed at a quarter before 11 o'clock. A meeting of the members of the Exhibition Association was held on Wednesday, Sir Thomas Clark in the chair. Mr. Pollard, the treasurer, submitted a report of liabilities, from which it appeared that they amounted to £40,733. 12s. 5d. The assets were: Concessions outstanding, £2,366; sums due by railway and electric launches, about £1,200; sums due for space, electric light, and storage, say, £600; cash in hand, £1,449. 14s. 9d.; value of the buildings as estimated, £10,000. The deficit, subject to cost of working and expenses of liquidation, amounted to £24,917. 17s. 8d. It was resolved to wind the association up voluntarily, and Mr. G. A. Robertson, chartered accountant, was appointed liquidator, a committee of advice being also elected. The Edinburgh Town Council guaranteed amounts to £1,000.

Sale of Electrical Plant.—On Friday, the 31st ult., we looked in at the sale of plant held by that well-known firm Messrs. Wheatley Kirk, Price, and Goulty, on the premises of the new station in course of erection for the Westminster Supply Corporation in Eccleston-place. There was not a very large attendance, and the bidding was a

trifle slack sometimes. And yet there was some very good stuff to be bought, and one or two real bargains to be had. Mr. Price held the hammer (a lead pencil), and from the vantage ground of a deal box alternately cajoled, expostulated, and cracked jokes as the occasion demanded. For the benefit of those who were not present, and to show how advantageously plant can be picked up at the sales held by the above firm, we will give the prices at which some of the items in the catalogue went. Sundry wrought-iron steam piping, apparently in good condition, with one injector and one steam valve, fetched 31s. A compound dynamo, giving 110 volts 330 amperes at 430 revolutions, by Goolden and Co., was bought in at £95. A polished slate switchboard, 4ft. by 3ft., with two main ring switches, single switch, and three fuses, went for £3. 10s. Twenty-four 2-light Edison and Swan electroliers, wired and with double switches, realised 3s. each. Twenty-three E.P.S. 15L cells in glass containers (1888 type) began at 10s. (about the price of the glass container, as Mr. Price pathetically remarked), and went for 18s. apiece. The auctioneer offered the buyer 20s. on the spot, but he was not to be had. These cells, by the way, were perfectly new, but had been badly handled in moving, and the positive plates were not what they ought to be. An Ayrton and Perry 150-volt voltmeter, calibrated a few days ago, reached 25s., and an ammeter of same design 35s. Twenty-eight feet of single 4in., and a similar length of double 7in. leather belting fetched £1. Forty-three feet of 5in. by 14in. leather link belting began at £3. 5s. and ran up to £6; while 54ft. of 9in. by 14in. Scandinavian canvas belt began at 10s. and was knocked down at £1. Two 1,500-watt Kapp and Snell transformers (what compact little things they are!), transforming from 2,000 to 100, fetched £2. 5s. each; another 3,000-watt apparatus of same design went for £2. 5s., and another similar 3,000-watt apparatus for £3. All these were new. Some new Jablochkoff transformers, however, did not find a bidder whilst we were there, and were passed. A 16-unit A type compound dynamo by Goolden and Co., to give 110 volts and 150 amperes at 960 revolutions, with set of stretching rails, began at £10 and fetched £45. Another 10½ unit G.T. shunt-wound dynamo, giving 140 volts and 75 amperes at 950 revolutions, with set of stretching rails, began at £5 and ran up to £17. 10s., at which price, there being no apparent desire on the part of bidders to go higher, Mr. Price said he certainly could not sell it.

St. Pancras.—The foundation-stone of the central station in process of erection by the St. Pancras Vestry was laid with due formality on Wednesday afternoon by the churchwardens of the parish, Messrs. Boden and Robinson. An inscription on the stone detailing the circumstance also mentioned the names of Mr. Andrew Sweet, chairman, and Dr. Walter Smith, deputy-chairman of the Electricity Committee, Prof. Henry Robinson, M.I.C.E., etc., engineer, and Mr. T. Eccleston Gibb, vestry clerk. The stone is let into the north wall of the engine-room that is to be. Prof. Henry Robinson gave some details of the installation, and stated that it "will serve the south-western part of the parish, and is intended to be followed by further stations to serve the rest of the district if the results are proved to be as satisfactory from a commercial standpoint as is anticipated. He had adopted the 'continuous current,' and had fixed the E.M.F. at 110 volts to suit incandescent lamps. The mains will be laid on what is known as the 'three-wire system,' by which arrangement the current is transmitted from the central station at 220 volts along the two outside wires, whilst the third wire is kept at an intermediate potential, differing from that of either of the outside wires by 110 volts. The lamps are in electrical contact with either of the outer wires, and with this third wire. Half the lamps are connected to one outside wire and half to the other. In the event of the demand being greater on one side than the other, it is met by a supply from the station along the third wire. This arrangement enables current to be supplied at 220 volts for purposes of motive power and arc lights, in addition to the supply at 110 volts for incandescent lighting. This is by far the most efficient and economical system of distributing electrical energy under conditions which obtain in St. Pancras. The central station plant will be capable of supplying low-tension current to serve 10,000 incandescent lamps of 16 c.p. simultaneously, and at the same time high-tension current will be provided on a separate set of mains to serve public lights in the streets, to the extent of 90 10-ampere arc lights, or a larger number of lamps of equivalent candle-power, at the outset. There will be nine low-tension and two high-tension dynamos, one of each sort serving as a stand-by or reserve. All the dynamos will be driven direct by triple-expansion condensing engines. There will be six sets of secondary batteries (capable of serving 800 or 900 lights) to work all the lights in use at periods of minimum demand when the engines and dynamos would not be working, and they will further act as an additional stand-by or reserve. Provision is made at the outset for five miles of distributing mains, which are designed to carry current for 25,000 incandescent lamps of 16 c.p. in use simultaneously, and separate mains are provided for the public street lighting. The St. Pancras parish now remains intact in the hands of the Vestry for the purpose of distributing electrical energy under a provisional order obtained in 1883. No company has as yet succeeded in obtaining powers within the area. He (the professor) congratulated the Vestry and the ratepayers on being in this unique position in the metropolis, as he was quite confident that time would show that a wise course had been followed in keeping the supply in their own hands, by which the ratepayers would get the electrical energy for either public or private lighting or for motive power, at the cheapest rate." Mr. Andrew Sweet, chairman of the Electricity Committee, in moving a vote of thanks to the churchwardens, said the estimated cost of the works then begun was £55,000, which it was proposed to borrow at 3½ per cent. from the County Council, the payment of principal and interest to extend over 42 years; and, at a very moderate computation, supplying the light at 6d. per unit, as against 8d. charged by private companies, he confidently anticipated that they would derive a yearly income which would yield them 20 per cent. upon the capital outlay. The buildings, of which the greater part of the foundations have still to be got out, are being pushed forward by Messrs. Kirk and Randall, the contractors for this portion of the work. A list of the other contractors for machinery, etc., will be found on page 281 of our issue of October 3rd last. Prof. Robinson very properly said that he would not indulge in congratulation, self or otherwise, until the scheme has been carried to successful issue. We may, however, echo the professor's hope that so it will be, and that the inhabitants of St. Pancras may have at no distant date to thank Prof. Robinson, Mr. T. E. Gibb, and the other gentlemen concerned, for bringing the best light there is to be had nowadays within their reach.

ELECTRIC MOTIVE POWER TECHNICALLY CONSIDERED.*

BY DR. W. L. ALLEN.

To go over the entire subject of electricity for street railways, and consider all technical details would occupy too much of your time. The subject naturally divides itself into—(I) The central station. (II) The transmitting line. (III) The motors.

The National Electric Light Association has so fully and exhaustively considered the matter of power or central stations that, most fortunately for street railway men, this subject is one that troubles us but little; but there are some points in which our work differs materially from engines of an electric lighting station.

The engine we require must be strong in all its parts, for there is no work where the demands on it vary so suddenly and so frequently, from the entire absence of load to the extreme capacity of the engine, as in street railway work. Some roads report that the cars average but 5 h.p. each. Supposing that such a road has eight cars in operation with one 150-h.p. engine in the station and, as is often the case, the cars either become bunched or happen to start at the same instant, here a sudden demand is made upon the engine for 150 h.p. or 200 h.p., while a moment later the meter may register but 40 h.p. You will, of course, be provided with safety-plugs and current-breakers, but you cannot allow safety strips to be blown out half-a-dozen times a day, possibly just at the moment you are ascending a heavy grade.

Electric light men state that a station with a number of small high-speed engines is more economical on account of being more flexible in its operation, but in their business the loads upon the station vary gradually, while we may be called upon at any moment for our maximum capacity. To arrange our station for this varying load, and at the same time avoid operating a tremendous engine on an average light road, is a problem that experience must solve for us. We are also more greatly troubled with lightning than we should be. There should first of all be established as perfect a ground connection as possible, either by means of a well or a deep hole; it is better to have two grounds, and thereby make sure of a moist contact for galvanised ground-plates or rods; then, with proper lightning arresters so placed that they can be conveniently examined and kept in order, we will be fairly well protected; but with our great lengths of exposed trolley wires we are very certain to have frequent calls upon our lightning arresters, and those in use at the present time are not such as to warrant perfect confidence.

Are we not all personally believers in the overhead system of transmission? What can there be simpler, cheaper, more durable, and more convenient? We have only poles, bare copper wire, galvanised iron span wires, insulators, and, where needed, additional feed wires, of which these last can be placed underground if desired. It is a rare thing to have a trolley wire break except at the curves. Curves are certainly troublesome on account of the constant liability of trolleys to jump off at some sharp angle, and the trouble is more generally due to fancy trolley stands, wheels, or springs, than to the overhead wire. For insulators we have only those for the straight line and those for the curves; and I show you a sample of each, such as were used two and a half years ago on one of our lines. It is not to be wondered at that street railway men at that time considered electricity, for the rough usage required by street railway work, to be in an embryonic stage of development. There is little to be asked for in the way of improvement of what we now have for overhead material. There is practically no difference whether we use the Thomson-Houston system, Sprague-Edison, Westinghouse, or what not. A single trolley wire which may be large and heavy, say 00, and thus afford feed wires where distance for transmission is not too great, or the wire may be small, say No. 4, light and easy to handle with, in that case, the necessary feed wires. We can take our choice and find equally good results with either. It will often be convenient to utilise both plans, with the large trolley in the central parts of the city where feed wires might be desirable, and with the small overhead and feed wires to reinforce the suburban parts. Undoubtedly the small wire is more easily handled and repaired in case of a break, and the feed wire prevents a dead line being the result of a break. The rail bonds may be galvanised iron, which cost but four cents, instead of tinned copper, and the supplemental ground wires can be of the same material. The supplemental wires do not give any better return except so far as to prevent a bad break in the return circuit, which might occasionally be caused by the breaking of both rail bonds at neighbouring joints. Rails on both sides of track should be connected with bonds.

It will not be necessary to discuss the merits of the conduit system or the storage battery. Actual experience has proven that there need be so little trouble or danger from the station and overhead line that we cannot concede the need of either conduit or storage battery, so far as we are concerned. It is true that the ever restless mind of the public has been so stirred up by accounts of the numerous successful storage battery and conduit railways that it has suddenly (and to us unpleasantly) become aware of the fact that we are using poles, and while we are congratulating ourselves upon the beauty and symmetry of our neat line of poles, it suddenly demands that we remove what it terms our unsightly poles. Nearly everyone of the street railway men present will uphold the statement that the only problem before us, and the one about which we are always anxious, is: "What can we do to keep our motors out of the repair shop?" We don't worry about our station or our overhead wires; we scarcely have time to think about them; we are constantly at work upon and perpetually annoyed by our motors; a lame armature, a burnt field magnet, a broken gear—these are our every-day trials. A motor—such as is made by the Thomson-Houston, Sprague-Edison, or Westinghouse Companies—has among its mechanical parts an axle gear and intermediate shaft gear, shaft pinion and armature pinion, and the axle and intermediate shaft and armature have each their boxes, or bearing. We want gear and pinions to be wide and heavy enough not to break. We don't want any more pinions like this, which was in use two years ago. We want gear of some material that will be reasonably durable, and at the same time noiseless; cast iron may do for the axle gear, which is large and runs slower, and steel for the intermediate shaft pinion; steel, we believe, is better than bronze, as it lasts longer and is less expensive. To overcome the noise it is necessary either to have the gear covered and running in oil, or to have the gear of wood or the pinion of rawhide. The large gear on the axle and intermediate shaft, if made with wooden teeth and used with steel pinions, certainly runs noiselessly, and it ought to make the life of the pinions much longer. Care must be taken to have the keys, in all gear and pinions tight and self-retaining. The shaft-boxes and bearings must be made of some compound metal that will not wear out too fast, for but little wear on the armature bearing will allow the armature to scrape on the pole-pieces of motor, be damaged and laid up for repairs. Aluminium bronze gives satisfaction as material for the bearings.

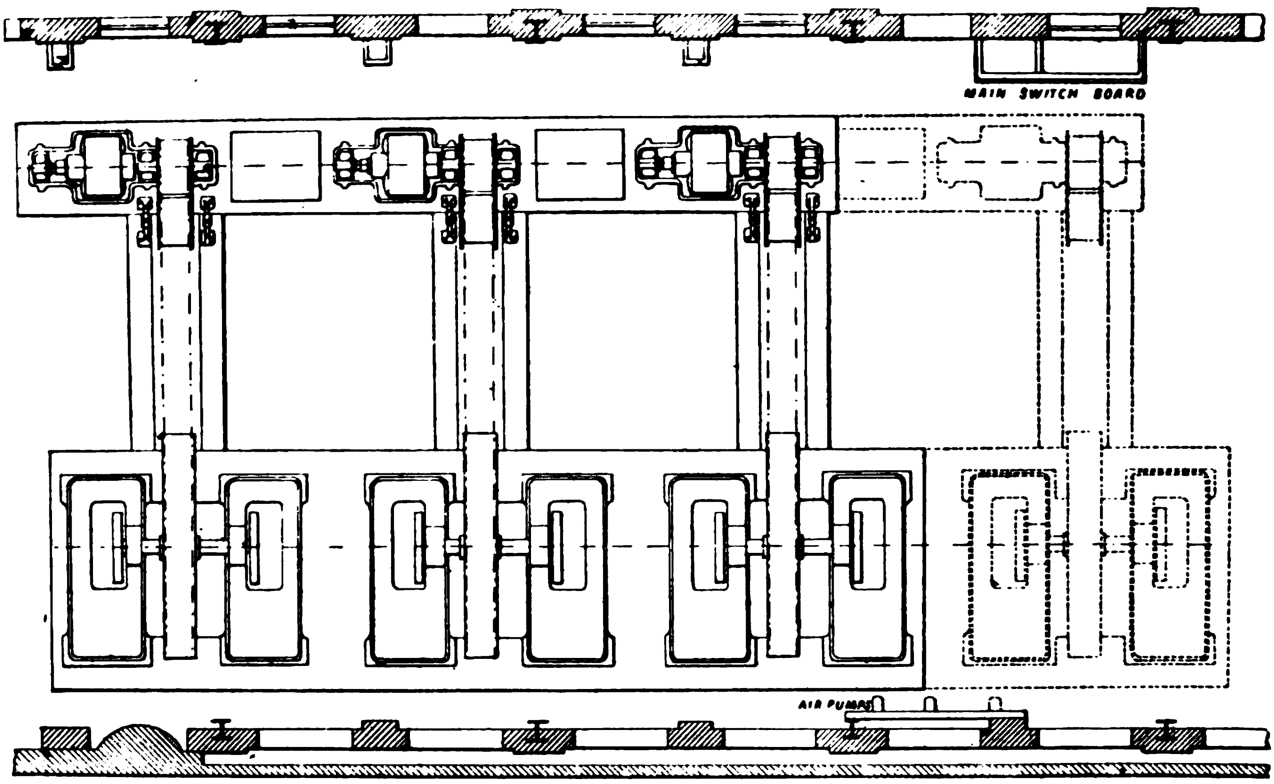
The electrical parts of the motor in which we are most interested are the armature, field magnets, and the controlling switch or rheostat. The armature of an electric motor is its wonderful and interesting, as well as its most expensive and troublesome, part. A street car is the most overloaded vehicle known to mankind. It may run a week with a light load and then suddenly receive enough passengers to load fairly well three or four ordinary cars; the motorneer may forget to oil either the car or motor, he may reverse motor accidentally or purposely to avoid an accident; these and many other causes require of an armature more work than it is capable of, hence, a burn-out. On the other hand, the armature itself may be at fault; an armature such as we use to-day consists of a shaft surrounded by a metallic core. Around this core is wound the best insulated wire, each coil terminating at the same end of the armature and being attached there by means of solder or screws to the bars of the commutator. The shaft of the armature will in a few years become worn by its bearings, and it would be well to have bushings or sleeves placed around shaft at those points, such as the Thomson-

* Paper read at the recent Street Railway Convention.

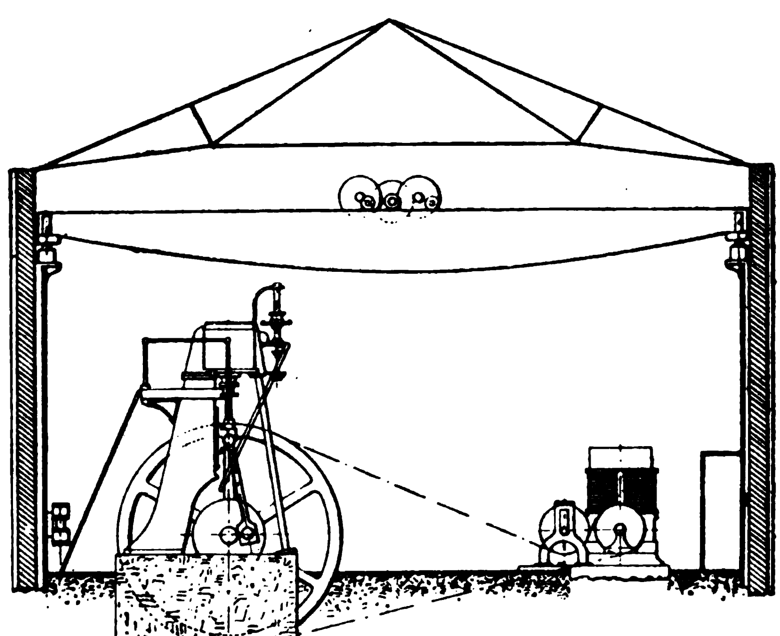
the mechanical trouble decreased to about 2 per cent. This decrease was probably due in some degree to a lighter business and less mileage. As the report does not state the nature or degree of the electrical disabilities, it is not fair to assume that they were all due to crippled armatures, but we can deduce from it that a car ought to run 100 days without electrical repairs.

THE CITY AND SOUTH LONDON RAILWAY.

On Tuesday the Prince of Wales opened what is, perhaps, one of the most remarkable railways in existence. and the history of its construction will form one of the most brilliant records in the history of engineering. As is natural, we devote our attention more especially to the electrical equipment of the line. Two systems of haulage only seemed applicable to a line of this kind—namely, by cable or by using electricity. The latter was finally adopted. As was well said in one of our daily contemporaries, "The most interesting portion of the works at the present moment—the depôt at the Stockwell Station, which contains that portion of the undertaking which henceforth will be upon its trial—is the electrical plant and power. The site occupied is a plot of about two or three acres on the surface, or ground level. Here are the



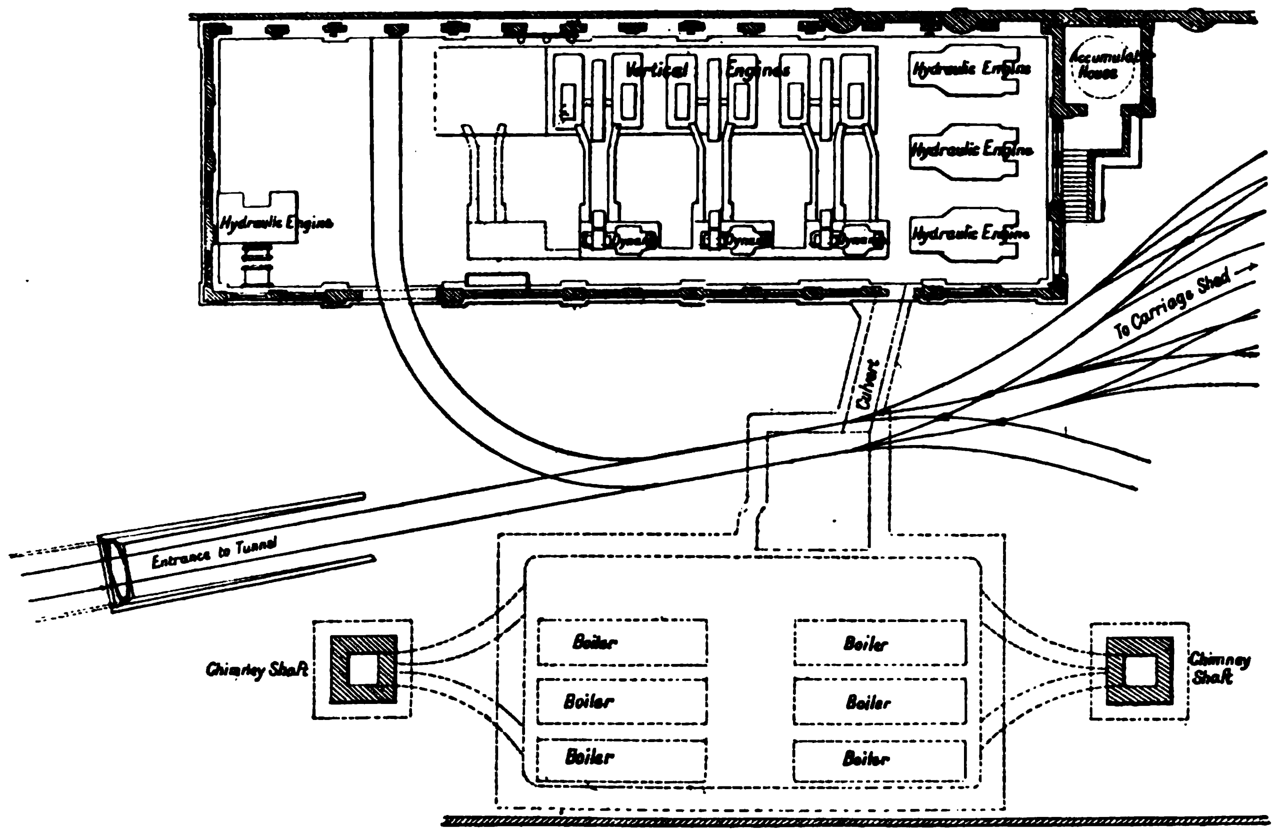
Plan of the Generating Station at Stockwell.—City and South London Railway.



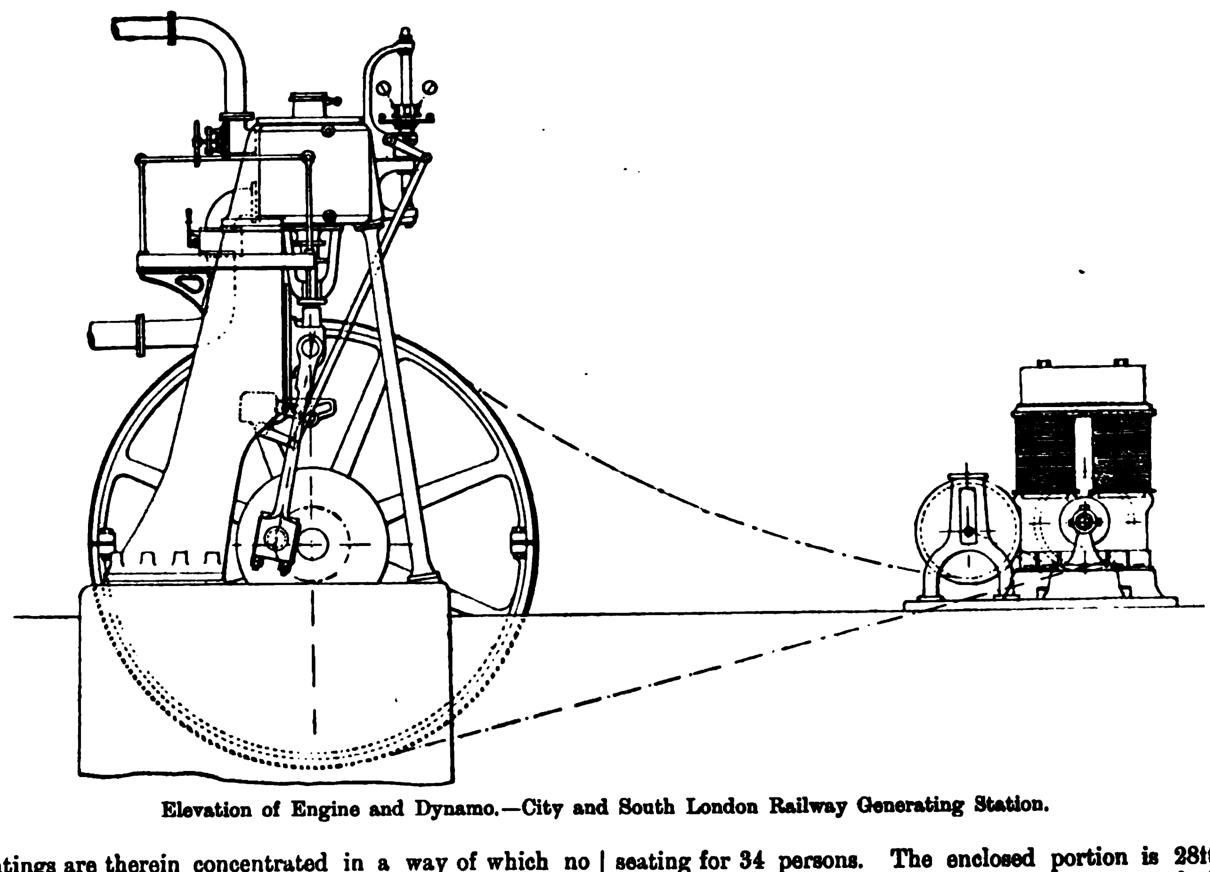
Elevation of Dynamo Room.—City and South London Railway Generating Station

We are now very familiar with underground railways, but this particular one is far deeper than any that has been previously constructed. It consists of two tunnels reaching from King William-street in the City to Stockwell. The engineering difficulties which have been encountered in the construction of this subway have been many and great, engine-house, train shed, repairing shops, and other requirements. The access between the depôt and the subway is by a curved tunnel descending from above ground by a steep incline of 1 in 3½ft. Up and down this the trains are brought or lowered by a rope and winding engine. This short bit of tunnel is remarkable. Formed on a horizontal

radius of 250ft. and a severe vertical radius, it is marvellous that the junction of the two drivings, one from below and the other from above, should have met centre for centre and level for level within an inch or two. The rails in it are laid on open sleepers; and crossings and switches and other intricacies of railway and roofed, but open at the sides above breast height. The locomotive contains two motors, the current for which is supplied through two contact slippers, which run along the conductor when the train is in motion. The long passenger carriages are pivoted on two four-wheeled bogies; and the interior, which is divided by a door in the centre, contains



Plan of the Generating Station at Stockwell.—City and South London Railway.



Elevation of Engine and Dynamo.—City and South London Railway Generating Station.

shuntings are therein concentrated in a way of which no other railway can show the like. At the depôt the carriage shed is large enough to contain six trains side by side. Each train consists of an electric locomotive and three passenger carriages 32ft. in length from end to end of the footboard. The locomotive is of iron, closed at both ends seating for 34 persons. The enclosed portion is 28ft. in length, the external overhang of the carriage platform being coupled up to the similar overhang of the adjoining carriage, and thus forming two open platforms between the three carriages. Upon each of these a guard travels with the train. These guards' platforms are protected at

the sides by iron lattice sliding doors. The carriages are lighted by electric light, the current for the lamps being, in like manner, taken off from the conductor. The electric generating station is a large white brick building, about 150ft. in length and 80ft. in width, and lofty in proportion."

This railway, as has been said, is constructed on a novel method designed by Mr. Greathead, M.I.C.E., in the form of two circular iron tunnels, 10ft. in diameter, driven through the London clay, and about 60ft. below the surface. The resident engineer is Mr. Mott, under whose immediate directions the work has been done.

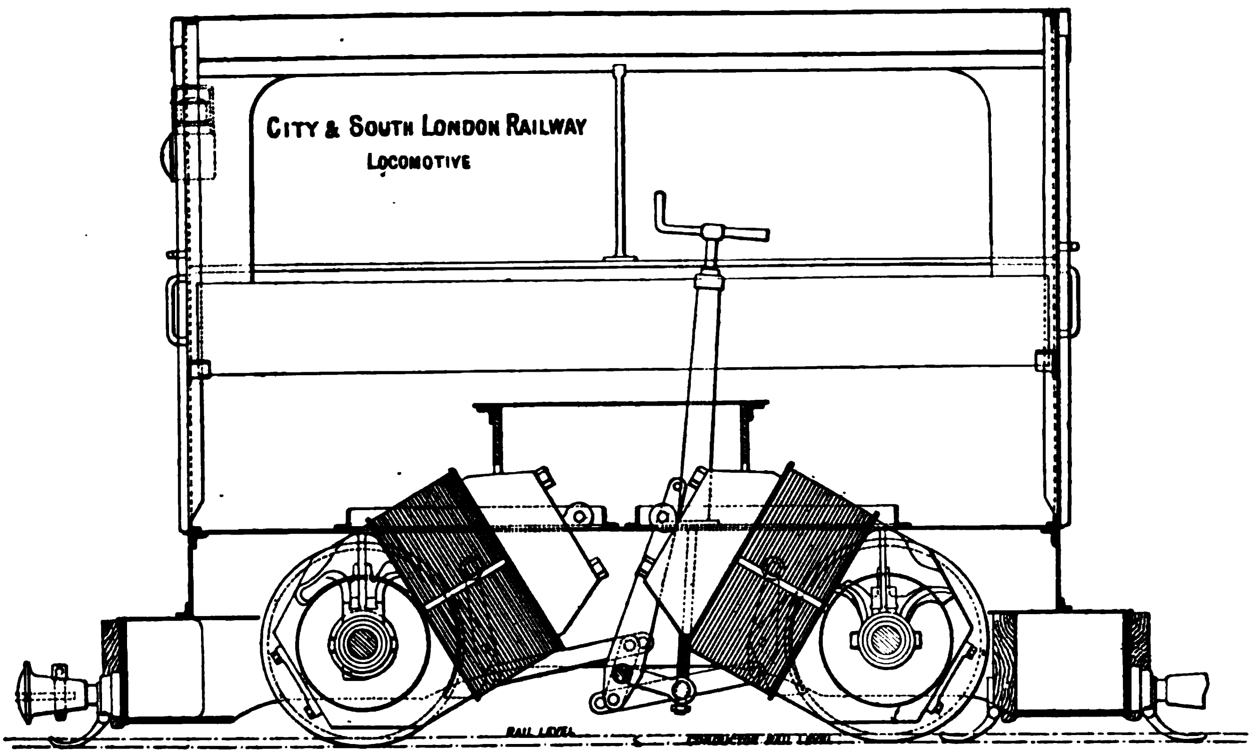
A scheme to work this railway by electricity, to avoid the use of steam and its noxious results, or the use of rope traction, with slow speed and other disadvantages, was submitted to the company by Messrs. Mather and Platt, engineers, Manchester. The company accepted the scheme, which is entirely original in its main features, though based upon the experience obtained by Dr. Edward Hopkinson, a partner of the above firm, in the construction of the Bessbrook and Newry narrow-gauge electrical railway in Ireland. The contract for the carrying out of the whole scheme designed by Messrs. Mather and Platt was committed to that firm. They have employed Messrs. John Fowler and Co., of Leeds, to supply the boilers and engines to work the dynamos for generating the current of electricity; also Messrs. Beyer, Peacock, and Co. to construct the framework of their electrical locomotives. The whole electrical plant has been carried out under the special superintendence of Dr. Edward Hopkinson, F.R.S., of the firm of Messrs. Mather and Platt. Dr. John Hopkinson has acted throughout as consulting engineer, and Mr. G. A. Grindle as resident electrical engineer.

A number of small tramways, both on the Continent and in the United Kingdom, have been worked electrically, and in the United States many of the street tramways are worked in this way, but it has not hitherto been applied on any large scale to the working of a railway of the usual gauge for passengers.

The following are the particulars of the plan of Messrs. Mather and Platt and details of various parts of the work.

The whole of the plant for generating the electrical current is situated at Stockwell, the suburban terminus of the line. At this point a complete plant has been erected for the generation of the electrical current. There are three large generator dynamos of the Edison-Hopkinson type, each worked independently by a vertical compound engine, designed and constructed by Messrs. John Fowler and Co. The engines work at a steam pressure of 140lb. per square inch, and have been built of exceptionally massive proportions. They run at 100 revolutions per minute, giving a piston speed of 450ft. per minute. They are fitted with automatic expansion gear of improved type on both the high-pressure and low-pressure cylinders, and are controlled by a powerful governor having a capacity of 750 foot-pounds, which is driven direct from the crankshaft by cotton ropes. The automatic gear being so arranged as to cut off the steam, if necessary, in both cylinders from dead cut off to ¾ of stroke. The engines will indicate up to 375 h.p. each. The cylinders are steam-jacketed, the high pressure is 17in. diameter and the low pressure 27in., stroke 27in. The pistons are fitted with Mather and Platt's rings and springs. The valves are specially arranged with multiple parts, which reduces their movement considerably and still gives a very prompt action; as the ports are as close as possible to the end of each cylinder, the loss of pressure by wire drawing is very small. The flywheels are 14ft. diameter and 28in. broad, and drive the dynamos direct by means of leather chain belts 26in. wide.

The engines are supplied with steam from six Lancashire boilers, 7ft. diameter by 28ft. long, which are fitted with Vicars mechanical stokers. Two large feed-water heaters are also supplied with brass tubes of ample surface for receiving the whole of the exhaust steam from the engine without back pressure.



Section of Mather and Platt's Electric Locomotive used on the City and South London Railway.

The generator dynamos are of the Edison-Hopkinson patent type with bar armatures, fitted with all the latest patented improvements of Messrs. Mather and Platt. The weight of the armature alone is about two tons, the weight of the entire machine being something over 17 tons. Each machine is capable of generating 450 volts and 450 amperes. The commutators are of hard copper insulated with mica. There are three brushes on each rocking arm, each separately adjustable with bring-forward thrust and hold-off catch. The magnet limbs are exceedingly massive, each limb with its pole-piece being over four tons weight, while the yoke of the machine weighs about three tons.

The machine can be run over as shunt or compound only as required. The total weight of copper wire on the magnet of each machine is nearly one and a half tons. The Edison-Hopkinson dynamo is well known as being one of the most efficient machine constructed.

The present machines have an electrical efficiency of 96 per cent., or slightly over, and the measured efficiency of the engine and dynamo—*i.e.*, ratio of the electric power available outside the dynamo to the i.h.p. of the engine—is over 75 per cent.

Sir William Thomson's multicellular electrostatic voltmeters are used for measuring the E.M.F. The current from the dynamos is conveyed to a general distributing and testing switchboard fixed in a recess of the engine-house. From this board the main circuits are taken to various parts of the line, and the current passing through each circuit is measured, and suitable arrangements are provided for switching over from one circuit to another.

The illustrations show a plan of the engine-house and also an elevation of the engines and dynamos. They explain themselves. We shall take another opportunity of illustrating and referring to the motor-engine.

The main cables have been manufactured by the Fowler-Waring Company, of North Woolwich, and consist of a copper core of $^{61}/_{14}$ B.W.G., insulated with Fowler-Waring patent insulating material, and lead sheathed.

The working conductor is of channel steel carried on glass insulators, the joints being fished, and also connected with copper strips. The general arrangement of the working conductor is exactly the same as that employed by Dr. Edward Hopkinson on the Bessbrook and Newry line. The steel employed is of very high conductivity, and has been rolled specially for the purpose by the Shelton Iron and Steel Company, of Stoke-on-Trent. The working conductor is divided into sections for convenience of testing and carrying out repairs on the permanent way. The insulation obtained is extraordinarily high. When the full pressure of 500 volts is on the complete system of working and feeding conductors, the leakage current does not exceed one ampere, so that the total loss by leakage is less than 1 h.p.; this is a small fraction of 1 per cent. of the total power required for working the line to its full capacity. The current is collected from the working conductor by sliding shoes of iron or steel arranged in a very similar way to that employed on the Bessbrook line.

Fourteen electric locomotives have been supplied by Messrs. Mather and Platt for working the line, each capable of developing up to 100 effective h.p., and of running up to 25 or 26 miles per hour. The armatures of the locomotives are constructed so that the shaft of the armature is the axle of the locomotive; in this way all intermediate gear and all reciprocating parts are entirely obviated. The method was suggested by the late Sir William Siemens some years ago, but has not as yet been employed elsewhere. The locomotives have a fixed wheel base and a motor is fitted on each axle, the axle not being coupled, but working quite independently. The current is conveyed from the collecting shoes through an ampere-meter to a regulating switch, then to a reversing switch, thence to the magnets, and back through the framework of the locomotive to the rails, so completing the electrical circuit. The locomotives are fitted with Westinghouse automatic air brake and also a screw hand brake, and they are lighted from the working conductor. The train when loaded will weigh 30 tons, and it is intended that 10 trains shall be worked on the line at one time.

The arrangements along the whole line for public traffic are well advanced. The lifts at all five stations are of the same type—namely, semi-circular in form, and carry 50 persons at a time. Two such lifts work in the same shaft 25ft. in diameter. No tickets will be issued at booking offices, but passengers entering from the roadways will pay their money and pass through turnstiles, going down by the lift or by stairs at their option. The carriages are all alike cushioned and comfortably fitted, there being no distinction between classes. The charge, too, will be uniform, twopence being the fare for the whole or any part of the distance. The limit of speed of the electric locomotive is 25 miles an hour. Ultimately the trains will follow each other at three minutes intervals, but at the commencement of the traffic they will start about 7.30 a.m. and run every five minutes. In all matters relating to the efficiency and security of working of the undertaking admirable forethought is evinced. The lifts have been provided by Messrs. Armstrong, Mitchell, and Co., of Elswick.

A NEW ASBESTOS-FACED VALVE.

The valve which we illustrate has been brought out to meet a want by supplying a flexible seating which can be renewed, if necessary, in a few minutes by an ordinary workman at a cost of a few pence, and for which no special tools are required. In the illustrations, A represents the form of seat adopted in this valve, which, in addition to the ordinary angled seat, has a round edge to prevent damage to the packing ring, B, when the latter is brought into contact with it. D is a loose valve, actuated in the ordinary manner by a screwed spindle working in gland of the valve top, which, when first set down, brings the packing ring, B, on to the seat, A, and for ordinary pressure a perfectly tight and elastic joint is thus made. But by setting the loose valve, D, hard down, the sliding cone, C, comes into contact with the angle of seat, A, and being free on the guide stud, E, is forced into the chamber of the loose valve, D, and by compressing the packing ring, B, prevents it from being damaged.

Bell's Asbestos-faced Vale.

When the packing ring, B, is thoroughly protected by the lower projection of the loose valve, D, there is little tendency for B to become damaged by the passage of steam or water through the valve, but even should it be entirely washed out, a tight metal to metal seating is the result by A, C, and D being brought closely together.

It is claimed that the valve, through its elastic seating, is not affected either by grit, dirt, expansion, contraction, or uneven seating, which makes it alike suitable for the highest or lowest pressures of steam, hydraulic, or general water valves by the insertion of packing rings made of the most suitable material to meet the various uses.

Bell's Asbestos-faced Valve—Section.

We understand that a 1½in. valve made under this patent, after being tested for three months at a steam pressure of 100lb. per square inch, has been found to hold perfectly tight. It was subsequently tested hydraulicly, and by being lightly screwed down held a pressure of 2,240lb. per square inch.

The packing ring used for these trials was made up specially in asbestos, and is still in perfect order, and we are assured it has not been removed at any time during or since the above trials. The valve is being introduced by Bell's Asbestos Company, of 118, Southwark-street, S.E.

THE

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Specimen copies of the paper will be sent on request.

"VIRES ACQUIRIT EUNDO."

We accept a quotation of the *Telegraph* when describing the opening ceremony of the City and South London Electric Railway, not, however, to apply it to the acceleration of the car, but because the quotation aptly describes what is happening with electric traction. Like the snowball, it too, gathers as it proceeds. Electric traction must expand and gather strength as time goes on. For a long time England has had to take a back seat in installation work, whether for lighting or power. Assisted by peculiar conditions, America has gone ahead till our light stations are comparatively few to theirs, and our power stations still fewer. But, after all, there is a solidity about the English way of going to work which, when carefully examined, must be admired by all. We do not admit having learned much from our cousins in lighting matters, but, undoubtedly, they have taken the initiative and possess the experience in traction matters. Their successes and their failures have been examples of work to be considered by us, to be followed or avoided according as they proved right or wrong. A few miles of tramways in England and Ireland is the sum of our previous work. The opening of the South London Electric Railway by the Prince of Wales on Tuesday inaugurates a new era in electric traction, and has removed a reproach. The engineering required to successfully cope with the proposed work thereon is of a far higher order than the successful equipment of an ordinary electric tramway served by overhead wires. It is a real application of electricity to railway work, though it must at once be admitted that many of the circumstances connected with this new line are extremely favourable to the success of electricity. We have none of the troubles with the conductors which arise in street traffic. No outside interference is possible. The whole system is under the absolute control of the superintending engineer. It is not our province here to describe the details of the work—that is done elsewhere; but we wish to point out the great claims of electricity for such work. There is one thing, however, that ought to come into the forefront, and that is a strong condemnation of newspaper men writing what is not true. The *Telegraph*, for example, in its article inculcates the idea that when coal may be exhausted, electricity will wholly or partly supply its place. So far as our information serves us at the *fin de siècle* this view is arrant twaddle and utter rubbish. At the present time lack of coal would certainly mean lack of that something which is commonly called "electricity." We suppose such writing goes down with the multitude, and schoolmasters and teachers have to contend against this dissemination of "evil knowledge." The men who write these articles are supposed to be scholars, and so far as quoting Latin and Greek, and certain

familiar lines from English authors, is scholarship, they have it and to spare. Heaven forbid, however, that in the near future this ability should constitute education. The mischief done by such men is incalculable, because they are assumed by their readers to be competent, nay, the very highest authorities—they must know, and from their words there is no appeal.

The two important properties that render electricity so suitable for underground working are, first, that its use greatly lessens the initial expense, and, secondly, that it simplifies the question of ventilation. Cable traction would be as suitable perhaps had the question of ventilation alone to be considered, but the initial cost of cable traction, and the constant cost of maintenance, would be far greater than with electricity. It is almost out of the question to employ steam, which has only the one recommendation of cheapness, though we do not accept the dictum that mere cheapness of generation determines the use of steam or of electricity. The incidental expenses that would be involved by the use of steam put it aside, hence the comparisons made of the contracted cost per train mile for electricity, and the ascertained cost per train mile for steam elsewhere, is of no value whatsoever. We have always thought that the method of computing train mile cost upon our railways is wrong. The total mileage run divided into the total expenses of every kind, gives the cost of a train mile. Upon the Stockwell line the true cost per train mile will be found this way, and not by asking what is paid to contractors. Before dividends are paid all expenses have to be met, and these are met by the receipts derived from running so many train miles. The use of steam on such a line as this might add twopence or tenpence per train mile to the expenses, though the direct comparison of coal and water, etc., consumed might be in favour of steam. The usual method of making comparisons then seems altogether misleading. In various quarters it has been suggested that breakdowns will probably be numerous, and may be dangerous. With regard to the former, who can prophesy? Can they be worse than the case of a suburban railway this last month, in which one particular train, it is said, broke down nine mornings in succession? Passengers do not like turning out, or being delayed, yet how few trains arrive punctually. The returns of the companies are no doubt not intentionally incorrect, but let anyone test the London, Chatham, and Dover; the South-Eastern, and one or two other lines by the station clocks, and we venture to think they will be unable to understand how it is that the returns show so great a percentage of punctual arrivals. With the Stockwell railway, punctuality should be the rule and not the exception. As regards danger, this seems reduced to a minimum. We trust that the successful opening of the line will be followed by a long and successful career, well knowing that no effort on the part of the engineers will be wanting to ensure this success.

ST. PANCRAS.

In a few towns the electric lighting has been kept in the hands of the authorities, but the metropolitan area has been pretty well divided up amongst various supply companies. However, the St. Pancras Vestry, following out long expressed views, will carry out the work for its own district, and hopes thereby to effect a considerable saving to the consumer. Here, then, we shall get cheek-by-jowl—the supply companies and the local authority working under similar conditions, and the future will tell us which is the better plan. Existing views on this question are divided, some supporting supply companies, others the authorities. If red-tapeism and jobbery can be kept out of the work, there is absolutely no doubt, in our opinion, but that the local authorities are the proper persons to supply the light. We are in favour of both water and light being under such control, and not in the hands of private companies. The St. Pancras authorities estimate that they can borrow the necessary money at 3½ per cent., repay principal and interest in a period of 42 years, and supply the light at 6d. per unit. At this price a yearly income is anticipated that will yield 20 per cent. upon the capital outlay. We think this a large estimate and sincerely hope the result may bear it out, but a more modest estimate would please us better. The local authority ought not to work for profit, and should sell the energy at such a price as would give sufficient revenue to pay all expenses and leave the amount required for repayment of capital and the interest.

CHELSEA VESTRY.

The Works and General Purposes Committee at the last meeting of the Vestry reported that they had considered the letter from Mr. Sydney Morse, on behalf of the Chelsea Electricity Supply Company, dated 29th July, applying for the consent of the Vestry, as the road authority, to a provisional order, authorising the company to construct tramways in this parish, notifying that the streets proposed to be included in the provisional order are "The King's-road, from the boundary of the Fulham parish, eastwards to Sloane-square, thence eastwards through Sloane-square to boundary of St. George's, Hanover-square, in Westbourne-place; the Fulham-road, from the boundary of the Fulham parish on the west to a point opposite the northern end of the Marlborough-road;" stating that the motive power to be adopted will be electricity, and asking for an opportunity of appearing before the Vestry, and laying their proposals before them in greater detail; and in connection therewith a letter from Mr. E. B. Trotter, secretary, West-end Tramways Opposition Association, dated 24th September, asking that an opportunity may be given to those interested in the route of the proposed tramways to lay any objections they may have to the scheme before the Vestry. The committee have had before them a deputation, consisting of Mr. Ernest B.

Trotter, 19, Great George-street, S.W., Major Frederick Josselyn, Stanley Works, King's-road, Mr. J. W. Bowden, 533, King's-road, Messrs. J. Wimsett and Son, 489, King's-road, Messrs. James Veitch and Sons, 544, King's-road, and Mr. W. Scarborough, The Mansions, Earls Court, who presented a petition bearing the signatures of 411 freeholders, leaseholders, and holders of property in the King's-road, Fulham-road, and elsewhere in the parish, as follows :

To the Vestry for the parish of St. Luke's, Chelsea.

The petition of the undersigned owners, lessees, and occupiers of land, houses, shops and other premises situate in King's-road and Fulham-road, Chelsea, showeth as follows :

1. Your petitioners are informed that the consent of the Vestry has been requested by the Chelsea Electricity Supply Company, Limited, to the laying down of tram lines along the King's-road and Fulham-road, Chelsea.

2. Your petitioners submit that the said roads are unfitted for the working even of a single line with safety. As to the King's-road (first) on account of its narrowness, especially between Paulton-square and Park-walk, and near Sloane-square; (second) because of the two bends in the road at right angles near Park-walk; (third) the lining of the road with costermongers' barrows in the evening; (fourth) the majority of the traffic being heavy traffic from the coal wharves and large manufactories and places of business, etc. As to the Fulham-road (first), on account of the narrowness of the road, especially near Drayton-gardens and Gilston-road; (second) the serious nuisance and inconvenience to five public hospitals; (third) the large traffic, especially at the junction with Redcliffe-gardens.

3. Tramways are not needed, there being ample accommodation for all requirements by omnibuses and other vehicles, as well as by the railways.

Your petitioners, therefore, respectfully urge the Vestry to withhold their consent to the proposed and to any similar schemes, and to use their best endeavours to induce the London County Council to take the same course.

A deputation consisting of Major-General Webber and Mr. S. J. Cluer also appeared before the committee in support of the application for the Vestry's sanction to the proposed scheme, and explained in detail the proposals of the promoters. The committee, however, having fully considered these proposals, together with the objections thereto urged in the aforesaid petition, recommended that the Vestry withhold their consent to this scheme, and that in the event of the promoters proceeding any further in the matter, the Vestry oppose it, and this was carried.

It seems that the opposition was principally, if not wholly, on account of the narrowness of the roadways.

ON DIFFERENT METHODS OF PRESSURE REGULATION IN DISTRIBUTING SYSTEMS AND THEIR RELATIVE COST.*

The ideal which all parallel working systems try to realise is the maintenance of an absolutely or at least nearly constant pressure on the terminals of the consuming apparatus (lamps, motors, etc.). Besides the practically impossible way of connecting each single apparatus by special wire to the collecting bars at the central station, there are different methods in use, which have, however, all one point in common, namely, to keep the pressure constant only at several points or centres of distribution in the network, the sections of which are so calculated that the fall of potential in them, even at full load, does not exceed the limits of safety allowed for the lamps. (The pressure for a 110-volt lamp may be exceeded up to, say, 111·5 volts without serious injury to the lamp.) At full load we allow about three volts to be lost from the junction of the feeders to the furthest lamp, and keep the pressure at the feeder points for light loads at 110 volts, increasing with the load to 111·5 volts. Now the methods only differ in the way by which the pressure is kept constant at the feeding points :

1. Regulation by an E.M.F.
2. Regulation by use of resistances.

The former method supposes a pressure at the collecting bars in the central station equal to the intended pressure at the feeding points, and to replace the loss of pressure in mains and feeders, either by storage cells or a separate dynamo, the E.M.F. of which in each moment is proportional to the current consumed.

The latter method consists in maintaining the station pressure at a higher value, the excess being equal to the loss of potential in the mains, when at full load; as each feeder gives a special drop of potential we must provide each one with a regulating resistance, by which the product C × R is kept the same for all, and where the regulating resistance may either be worked by hand or automatically.

In the following the cost and the relative merits of these four methods will be considered, although at first sight it may appear as if the regulation with an E.M.F. would prove of greater advantage than the resistance methods, because no energy is wasted in heat and because such a station would be able to supply current at the required pressure to the adjacent districts without other regulating device. On the other hand, the apparatus required for this method is far more expensive than resistances, and only a special investigation of the case could decide upon the method to be adopted.

We have to establish a formula for each of the four methods, representing the total annual cost of the regulation, composed of

α. Cost of generating the electrical energy, which is transformed into heat in the feeders.

β. Interest and depreciation of regulating gear and feeders.

γ. If regulation be done by hand, extra expense for wages.

For this purpose we have first to find out the economical section of the feeders, and then to represent the annual cost as a function of the number, length, and maximum current of the feeders.

A. Regulation with Accumulators.

The following calculations apply only to a regulation by hand : if P be the highest loss of potential in one feeder, C the maximum current, then the price in shillings for the cells required will be K . P . C.

The price, K, of the cells per one watt maximum output is, according to the price list of Müller and Einbeck (cells for heavy discharge) for 1·85 volts per cell, about 8d., including packing. An allowance of 10 per cent. must be made for the number of cells on account of the fall of the E.M.F. with the discharge.

The prime cost for the cells in one feeder, therefore, 1·1 × 0·66 P . C sh.; 13 per cent. interest and depreciation makes an annual cost of

$$0{\cdot}13 \times 1{\cdot}1 \times 0{\cdot}66\ \mathrm{P}\,.\,\mathrm{C} = 0{\cdot}0944\ \mathrm{P}\,.\,\mathrm{C}\ \text{sh.}$$

If L and Q are respectively the length in metres and sectional area in square millimetres of the feeders, and the specific conductivity of the copper be 55, we can express the resistance of the feeder as $\frac{2\,\mathrm{L}}{55\,\mathrm{Q}}$, and the value of $\mathrm{P} = \mathrm{C}\frac{2\,\mathrm{L}}{55\,\mathrm{Q}}$; the annual cost therefore is

$$0{\cdot}0944\,\frac{2\,\mathrm{L}}{55\,\mathrm{Q}}\,.\,\mathrm{C}^2 = 0{\cdot}00343\,\frac{\mathrm{L}}{\mathrm{Q}}\,.\,\mathrm{C}^2\,. \quad . \quad (1)$$

The price of iron-armoured lead cables with one pilot wire is 2 L (0·025 Q + 2·5) = 0·05 L Q + 5 L shillings, and their annual cost, allowing 8 per cent. for interest and depreciation,

$$0{\cdot}004\,\mathrm{L\,Q} + 0{\cdot}4\,\mathrm{L}\ \text{sh.} \quad . \quad . \quad . \quad . \quad (2)$$

The annual loss of energy $= \frac{2\,\mathrm{L}}{55\,\mathrm{Q}}\int c^2 dt$ (the current, c, at a given time $= j\,.\,\mathrm{C}$), therefore annual loss of energy

$$= \frac{2\,\mathrm{L}}{55\,\mathrm{Q}}\,\mathrm{C}^2\int j^2 dt = \frac{2\,\mathrm{L}}{55\,\mathrm{Q}}\,\mathrm{C}^2\,.\,753.$$

$$= 27{\cdot}4\,\frac{\mathrm{L}}{\mathrm{Q}}\,\mathrm{C}^2\ \text{watt-hours,}$$

which is the work to be done by the accumulators. (The integration of $\int j^2 dt = 753$ is obtained by observations made at different central stations during one year, and taking the average value.)

The accumulators having an efficiency of 75 per cent., the above value of the work done by them must be increased to

$$\frac{27{\cdot}4}{0{\cdot}75}\,\frac{\mathrm{L}}{\mathrm{Q}}\,\mathrm{C}^2\ \text{watt-hours, or}\ 0{\cdot}0486\,\frac{\mathrm{L}}{\mathrm{Q}}\,\mathrm{C}^2\ \text{h.p. per hour.}$$

The price of 1 h.p. per hour would be 1d., or 0·083

* From an article by Dr. Gustav Rasch.

shillings at the central station. This gives the annual cost of the energy wasted

$$= 0{\cdot}00412 \frac{L}{Q} C^2 \text{ sh.} \quad . \quad . \quad . \quad . \quad (3)$$

The total cost of maintenance will be

$$0{\cdot}00343 \frac{L}{Q} C^2 + 0{\cdot}004\, L\, Q + 0{\cdot}4\, L + 0{\cdot}00412 \frac{L}{Q} C^2 \quad (4)$$

This equation has for $Q = 1{\cdot}37\ C$ (economical section) its minimum value—namely, $0{\cdot}011\ L\,C + 0{\cdot}4\ L$.

Now, for n mains $0{\cdot}011 \sum_1^n L\,C + 0{\cdot}4 \sum_1^n L$.

An attendant being able to look after two or three feeders at once, and considering his other services in the station, we may fix the cost of attendance per feeder and day = 3½d., therefore per year = 110 shillings. The complete annual cost is, therefore,

$$110\, n + 0{\cdot}011 \sum_1^n L\,C + 0{\cdot}4 \sum_1^n L \quad . \quad . \quad . \quad (A)$$

Regulation with a Special Dynamo (Lahmeyer's System).

The price of one regulating dynamo for P . C watt may be written

$$0{\cdot}256\ P\,.\,C + 545 \text{ sh.} = 0{\cdot}0093 \frac{L}{Q} C^2 + 545 \text{ sh.}$$

With 11 per cent. for interest and depreciation (machine almost without stress),

$$\text{Annual cost} = 0{\cdot}00102 \frac{L}{Q} C^2 + 60 \text{ sh.} \quad . \quad (5)$$

For the cables as above, $0{\cdot}004\ L\,Q + 0{\cdot}4\ L$ sh. . (6)

Energy wasted in heating the feeders as before

$$27{\cdot}4 \frac{L}{Q} C^2 \text{ watt-hours or } \frac{27{\cdot}4}{746} \frac{L}{Q} C^2 \text{ h.p. per hour.}$$

If the efficiency of the regulating dynamo be 83 per cent., of the main dynamo 92 per cent.; the cost for 1 h.p. from the regulating dynamo is thus $0{\cdot}083 \frac{92}{83} = 0{\cdot}089$ sh., therefore cost of lost energy

$$0{\cdot}089 \frac{27{\cdot}4}{746} \frac{L}{Q} C^2 = 0{\cdot}00328 \frac{L}{Q} C^2 \text{ sh.} \quad . \quad . \quad . \quad (7)$$

For one feeder the total annual cost $0{\cdot}00102 \frac{L}{Q} C^2 + 60 \text{ sh.} + 0{\cdot}004\ L\,Q + 0{\cdot}4\ L + 0{\cdot}00328 \frac{L}{Q} C^2$; the minimum value of which for $Q = 1{\cdot}04\ C$ may be written

$$0{\cdot}00832\ L\,C + 0{\cdot}4\ L + 60.$$

The complete expression for n feeders

$$0{\cdot}00832 \sum_1^n L\,C + 0{\cdot}4 \sum_1^n L + 60\,n \quad . \quad . \quad . \quad (B)$$

As the regulation is automatic, we need not add any wages.

A distinct difference in the calculation has to be made between resistance regulation by hand or automatically, because in the former case we are able to follow the fluctuations of the potential drop, while with automatic regulators we must keep the station pressure always at its maximum value. Besides, we have to take into calculation that, in contrast to the E.M.F. methods, the regulation by resistances require $(n+1)$ feeders—*i.e.*, one feeder more for the district surrounding the station itself.

Resistance Regulation by Hand.

Feeder 1 is supposed to carry the heaviest load, its resistance may always remain short-circuited, and the regulation will be done at the dynamo.

The current through 1 be $c_1 = j\,C_1$, and its drop of potential P. The nature of the method then requires

$$\left.\begin{aligned} P &= c_1 \frac{2\,L}{55\,Q_1} = c_1 W_1 \\ P &= c_2 \left(\frac{2\,L_2}{55\,Q_2} + R_2 \right) = c_2 W_2 \\ &\cdots\cdots\cdots \\ P &= c_k \left(\frac{2\,L_k}{55\,Q_k} + R_k \right) = c_k W_k \end{aligned}\right\} \quad . \quad . \quad . \quad (8)$$

The loss of energy in feeder $k = P\,.\,c_k = c_k^2 W_k = C_k\,.\,C_1 W_1\,.\,j^2$.

The annual loss of energy $= 753\ C_k C_1 W_1$.

$$= 753\ C_k^2 \left(\frac{2\,L_k}{55\,Q_k} + R_k \right).$$

the cost of which amounts to

$$\frac{753}{746} \times 0{\cdot}083\ C_k^2 \left(\frac{2\,L_k}{55\,Q_k} + R_k \right) = 0{\cdot}0837\ C_k^2 \left(\frac{2\,L_k}{55\,Q_k} + R_k \right)$$

shillings. Cost of cables, the same as above; therefore, total annual cost

$$0{\cdot}004\ L_k Q_k + 0{\cdot}4\ L_k + 0{\cdot}0837\ C_k^2 \left(2 \frac{L_k}{55\,Q_k} + R_k \right).$$

This expression becomes a minimum for $Q_k = 0{\cdot}87\ C_k$—namely, $0{\cdot}004\ L_k \times 0{\cdot}87\ C_k + 0{\cdot}4\ L_k + 0{\cdot}0837\ C_k C_1 W_1$, which must be equal to $0{\cdot}00344 \sum_1^n C\,L + 0{\cdot}4 \sum_1^n L + 0{\cdot}00346\ L \sum_1^{n+1} C$. The price of each resistance being 20 sh., we have 2 sh. for its interest and depreciation, and for all together $(n+1)$ 2 sh. Wages the same as in method (A) gives a complete annual cost

$$112\,(n+1) + 0{\cdot}00344 \sum_1^n C\,L + 0{\cdot}4 \sum_1^n L + 0{\cdot}00346\, L_1 \sum_1^{n+1} C \quad (C)$$

Automatic Regulation by Resistances.

If the maximum loss of potential for the evening be $C_1' W_1$, which is the amount the pressure at the collecting bars has to be increased during all the evening. The loss of energy caused by the current c_k in the feeder $k = C_1' W_1 c_k$, and during the evening $C_1' W_1 \int c_k\, dt = C_1' C_k W_1 \int j\, dt$.

Now let us write $C_1' = \eta\, C_1$ ($\eta = j$ max. for the day) we have as loss of energy $C_1 C_k W_1\,.\,\eta \int j\, dt$.

	Jan.	Feb.	Mar.	April	May	June
η.........	0·9	0·9	0·79	0·64	0·63	0·55
$\eta \int j\, dt$..	4·83	3·87	2·74	1·72	1·39	0·84

	July	Aug.	Sept.	Oct.	Nov.	Dec.
η.........	0·56	0·66	0·7	0·9	0·96	1·0
$\eta \int j\, dt$..	1·08	1·60	2·08	4·11	5·45	5·74

Average value per year, 1,080.

Annual loss in $k = 1{,}080\ C_1 C_k \left(\frac{2 L_k}{55 Q_k} + R_k \right)$ watt-hours, the cost of which is $\frac{1{,}080\ .\ 0{\cdot}083}{746} C_1 C_k \left(\frac{2 L_k}{55 Q_k} + R_k \right) = 0{\cdot}115\ C_1 C_k \left(\frac{2 L_k}{55 Q_k} + R_k \right)$.

Price of cables as above.

The total $0{\cdot}004\ L_k Q_k + 0{\cdot}4\ L_k + 0{\cdot}115\ C_1 C_k \left(\frac{2\,L_k}{55\,Q_k} + R_k \right)$ will be a minimum for $Q_k = 1{\cdot}03\ C_k$, namely, for all the feeders together, including 60 shillings interest and depreciation for each regulator.

$$0{\cdot}00412 \sum_1^n L\,C + 0{\cdot}4 \sum_1^n L + 0{\cdot}00414\, L_1 \sum_1^{n+1} C + 60\,(n+1) \text{ sh.} \quad . \quad . \quad (D)$$

In order to decide as to the relative merits of the four methods, we have to make several limiting suppositions; in all these cases, where the feeders are of very different length, it is not advantageous to adopt the resistance method, because the economical section of the feeder is proportional to the maximum strength of current, and therefore the allowable loss of potential proportional to the length of the feeder.

Now let us suppose that all feeders are of equal length, and their load also pretty nearly the same.

Case I.—300 lamps of 0·5 amp. each = 150 amp. for one feeder

$$L = \begin{cases} 100 \text{ m.} \\ 400 \text{ m.} \end{cases}$$

	$n=3$ 4=100	$n=10$ 4=100	$n=16$ 4=100	$n=3$ 4=400	$n=10$ 4=400	$n=16$ 4=400
Accumulator	945	3,150	5,040	2,790	9,300	14,900
Dynamo	675	2,250	3,600	2,160	7,200	11,500
Hand resistance...	932	2,724	4,260	2,380	7,180	11,320
Automatic	794	2,362	3,702	2,460	7,490	11,760

For small plants the regulation with dynamos is favourable, whilst for larger plants it is better to use hand regulation with resistances. The accumulators, it must be remembered, may also be used for other services, and will therefore be cheaper than was supposed here; they offer a reserve which could not be obtained so cheaply with another method.

CASE II.—500 lamps = 250 amperes per feeder.

—	$n=3$ 4=100	$n=10$ 4=100	$n=16$ 4=100	$n=3$ 4=400	$n=10$ 4=400	$n=16$ 4=400
Accumulator	1,275	4,250	6,800	4,110	13,700	21,900
Dynamo	924	3,180	4,928	3,156	10,520	16,850
Hand regulator ...	1,172	3,438	5,382	3,344	10,978	15,860
Automatic	1,083	3,223	5,059	3,612	10,930	17,180
CASE III.—700 lamps = 350 amperes per feeder.						
Accumulator	1,605	5,350	8,560	5,430	18,100	28,960
Dynamo	1,173	3,910	6,256	4,152	13,840	22,140
Hand regulator ...	1,412	4,163	6,521	4,304	12,960	20,370
Automatic	1,372	4,095	6,429	4,768	14,400	22,660

Since the cost of 1 h.p. varies very much, these results vary also.

INDUSTRIALISM.*

BY W. B. ESSON.

When the Old Students' Association did me the honour to nominate me as president, I mildly suggested that by way of innovation this address might be dispensed with. The committee received that proposal, however, with open derision. Individually and collectively it smiled while declaring that the suggestion had been made before, annually in fact, and just as often as a president had been nominated. The committee remaining inexorable, the serious business of choosing a subject had to be considered, and I may confess that considerable difficulty was experienced in the selection. One does not want to talk as a specialist on such an occasion, as the address can then interest but a few. One wishes, if possible, to say something in which all the members will feel some interest, notwithstanding the diversity of the pursuits in which they may be severally engaged. And surely there is in their occupations plenty of variety. The Old Students' Association includes among its members men occupying positions in every department of applied science. In the numerous branches of civil and mechanical engineering, in departments devoted to the several applications of electricity, and in most of the great chemical industries we find the Old Students' Association represented. And this, I believe, is common to most of the representatives, that each in his particular sphere strives with might and main to achieve success.

But whatever branch of industry we may be engaged in, at some time or other we have attended the classes for technical instruction, conducted under the auspices of the City and Guilds of London Institute. It may have been for a long or short period at the Central Institution, at the Finsbury Technical College, or in a subterranean chamber in Cowper-street, before either of those places was built. Anyhow, the scattered members of this association, with their many diverse interests, are united by the bond of that old studentship and the memories which cling around it. True, we can boast of no ancient pile or venerable quadrangle echoing the voices of the past, but if we are without the historical associations and traditions of an ancient university, we are at least free from its "dead languages and its undying prejudices." We are distinctly with the moderns. We went in for a liberal education, and for such preparation as was, rightly or wrongly, conceived to best fit us for rising to a place from the ranks of modern industry. Our object was to win, if possible, in the industrial struggle—in short, to make a living.

And here, I think, we touch common ground. We are all engaged in fighting, with more or less success, the battle of life. We are all performing some function in the world of industry. We are all trying to make a living. In endeavouring to find a suitable subject for my address these reflections occurred to me, and it then struck me that I might occupy your attention for a short time with the all-important subject of industrialism, a topic of vast interest to all classes of the community, since it involves problems the solution of which is becoming pre-eminently the question of the present as it will be that of the future.

Industrialism is a growth, and the present highly specialised methods of production have been evolved gradually from the ruder processes of the past. In savage communities there was no variety of individual occupation. By turn a warrior, a hunter, a fisherman, a tool maker or builder, each lived independently of his neighbour, concerted action only being taken for the purpose of defence. But in time individuals showed special aptitudes for particular kinds of work. Some displayed special abilities in making weapons, while others, more intrepid and courageous, showed a more decided inclination to use them. In a sort of understanding that the men who made the weapons would be furnished with food by the hunters who used them, we can easily understand a crude division of labour to have had its origin. From a remote savagery through the ages which elapsed before men began to learn much of the arts of civilisation, the principle of the division of labour continued to develop the skill afterwards directed towards the arts of civilisation, being first engendered and fostered by the arts of war. "If we go back to the Stone Age," says Mr. Herbert Spencer, "we see that the implements of the chase and the implements of war are those showing most labour and dexterity. If we take still existing human races which were without metals when we found them, we see in their skilfully-wrought stone clubs, as well as in their large war canoes, that the need of defence and attack were the chief stimuli to the cultivation of arts afterwards available for productive purposes. Passing over intermediate stages, we may note in comparatively recent stages the same relation. Observe a coat of mail, or one of the more highly-finished suits of armour—compare it with articles of iron and steel of the same date; and there is evidence that these desires to kill enemies and escape being killed, more extreme than any other, have had great effects on those arts of working in metal to which most other arts owe their progress. Indeed, it may be questioned whether in the absence of that exercise of manipulative faculty which the making of weapons originally gave, there would ever have been produced the tools required for developed industry."* But in addition to fostering industrial art, war slowly brought about the conditions which made an industrial state of society possible. It was by force of arms that small nomadic hordes were welded into large tribes, that tribes were welded into small nations, and that small nations were welded into large nations. Only by the social aggregation arising from warfare were produced the conditions under which the division of labour could be developed to any considerable extent.

Contemporaneously with the development of industry grew the distinction which gradually become more emphasised between the regulating and the regulated classes. In primitive tribes the chiefs worked like other members with their own hands, and were only distinguished from them by more than usual valour exhibited in attack or defence. All fought when the need arose, and the separation of the chief from the rest of the tribe, his ceasing to work with his own hands, his gathering around him warriors distinguished by their valour, his dividing amongst them the lands of conquered races, the rise of feudalism, its ultimate decay and the advent of wage-paid labour were amongst changes which the slow roll of centuries gradually brought about.

Coming to the middle ages, we find the arts of civilisation considerably advanced; towns growing and industrialism advancing as militancy decreased. The oppression of feudal lords pressed hardly, however, on the growing industries, and labour was burdened with heavy taxes to maintain large numbers of military retainers in a state of idleness and comparative luxury. "The old freemen formed their frith guilds against the tyranny of mediæval magnates,"† and to defend themselves against the extortionate demands of lawless barons who were continually waging war against each other and levying the cost of their "expeditions" on the struggling industries. The history of those old-world combinations is extremely interesting reading, but here we have no time to do more than mention their existence; we are only skimming over their history in order that we may more completely realise that the present is unquestionably born of the past.

"So long as the towns were struggling against adversity, all the citizens worked together with public spirit and enterprise to secure their common welfare, but when a town had fully achieved its freedom and began to prosper, the oldest families of traders began to insist on their own privileges as the only proper full citizens and as members of the town guild."‡ While it was necessary they welcomed the combination of the craftsman against their common enemies, but as the need for such combination diminished the aggressiveness they manifested against their inferiors increased. To resist the pretensions of the old burghers, those who worked at different trades accordingly formed themselves into craft guilds, and for many generations the struggle between the two classes was carried on. But at length the victory was gained by the younger and more vigorous combinations of handicraftsmen. "In one town after another the craft guilds, leaguing together, overthrew the town guilds, and obtained mastery of the town,"§ governing it afterwards in their place for many generations.

In early times comparatively little capital was required for production. Industry was carried on by hand labour, and there was no expensive machinery to purchase and keep in repair. Then, the advantage of gathering many workers under one roof had no existence, and employer and employed were practically on the same level. Each craftsman worked with his own hands and in the same room with his workman, being aided by two or three hired journeymen and an apprentice, who became in course of time a craftsman himself The relation of master and servant was, in those days, almost patriarchal in its character. The man was brought into close contact with his employer daily and hourly, and the identity of interests was recognised by both, for the class war between capital and labour had not as yet commenced. Again, good work was done in these old days. The guilds took care that only capable craftsmen should be permitted to join their association, and the standard of work was well kept up. They were

* Presidential address delivered to the Old Students' Association of the City and Guilds of London Institute at Finsbury College, November 6, 1890.

* Herbert Spencer, "The Study of Sociology," page 194.

† Brentano's "Introduction to English Guilds," p. 195.

‡ Marshall's "Economics of Industry," p. 46. § *Ibid*, p. 46.

charitably inclined, and insured the worker and his family against want in case misfortune overtook them. While their influence lasted, the guilds were in many ways useful, but they had their day, and a time came when the attempts to regulate trade, and the various restrictions they imposed on industry, became harmful. Then came a reaction, and the guilds had to go, as have all institutions which lack the power to adapt themselves to a changed condition of existence. They lost their influence; advancing industry would not be restrained in the old grooves, and the guilds refusing to yield, it forthwith burst the barriers they had set up, and moved on in spite of them.

I have said that in early times there was little difference socially between the craftsman and his journeyman. But time brought a change in this respect. The craftsmen prospered, and their savings accumulated; capital began to grow, and the gulf between master and man, which was at first an almost imperceptible fissure, gradually widened. The former had grown rich, and had ceased to work with his own hands, or associate with his workmen. As his wealth grew he employed more labourers, whom he treated in much the same way as he himself had been treated by the old burghers in former times; and in combining to protect themselves against the aggression of the rising capitalist, the workmen followed the example set by the craft guilds when they resisted the claims of the frith guilds. So we see that there is manifested the same kind of tendency all through the history of industry. Nor is the reason far to seek. While tribes were engaged in constant strife, industrialism was born and nursed in the lap of warfare. The arts were cultivated chiefly as a means of defence against the inroads of enemies or of conquering neighbouring tribes. Men were barbarians, and their adaptation to the restraints imposed by their living in the society of others had scarcely begun. Through centuries of warfare, of violence and bloodshed, industrialism slowly struggled, civilisation progressing painfully and only as fast as savage hordes settled down to peaceful occupations. But though warfare nursed industrialism, consolidated scattered tribes, and by its discipline converted a savage incapable of continuous application into the man who, as a citizen, works from morn till eve, it left, alas! its bitter traits behind. In early times every member of the tribe was a fighter, and only slowly was the separation, at first partial, between soldiers and citizens accomplished. The latter were liable to be called upon for military service for a long period, and when the separation was complete it was a soldier who had become a citizen—a soldier, inasmuch as he or his ancestors had been trained in cruelty, disciplined in butchery, had been schooled in treachery, and had revelled in bloodshed. And with this inheritance from the past, bearing in mind how slowly human nature changes, and how very gradual has been the process of adaptation to the social condition so far, is it any wonder that citizens should have manifested, though in a less degree, the aggression and the cruelty and the persecution of former ages? Is it matter for surprise that industrialism should have displayed to a large extent the character of the militancy from which it was developed?

But we come now to the end of the seventeenth or beginning of the eighteenth century, when began that new era of steam, by which the world has been revolutionised. It was for pumping the water out of mines that Thomas Savery, in 1698, took out his patent for an engine to raise water by fire. I need not describe this engine, which to most of you is probably well known. As a pumping engine it was, of course, very inefficient, its duty being something less than one-tenth that of a modern one. But there is one thing I would mention here as illustrating the opposition at that time to the introduction of any appliance which appeared to dispense with hand labour or render a less number of workmen necessary. In a letter addressed to the "Gentlemen Adventurers in the Mines of England," Savery apologises, in a measure, for his invention, saying, "As for pump making, that part of the trade will be much improved by my engine, for I must use board and timber for pipes, and have considerable employment for pump-makers and carpenters for timber used about my engine. For my design is not in the least to prejudice the artificers, or, indeed, any other sort of people by this invention, which, on the contrary, is intended for the benefit and advantage of mankind in general." This language from an inventor implies the state of feeling at the time with relation to labour-saving devices. In 1712, an improved pumping engine was erected at Wolverhampton, by Newcomen and Cawley, who gave us the beam to be found in the modern type. Following Newcomen, we had Smeaton and others, who made great improvements, but it was left for the genius of Watt to make, from 1769 to 1782, those radical changes which have stamped the great inventor for all time as the father of the modern steam engine. At first his engine, like previous ones, was used only for mining purposes; but soon he invented his methods of converting the reciprocating motion of the beam into the rotatory motion required for working machinery. For the pump rods were substituted the connecting rod, with its sun and planet wheels; the steam engine was thus rendered applicable to any purpose of industry, and became the greatest power for good—some would say for evil—the world has ever seen.

In the middle of the eighteenth century the industries of the country were carried on, to a large extent, in the homes of the operatives. In the first stage of cotton manufacture, for example, the weavers, dispersed in cottages throughout the country, wove their webs from yarn spun by their wives and children on the common hand-wheel or distaff. At the same time, the weaver cultivated a small patch of ground, and to us, living midst the moil and toil of this nineteenth century, the picture of domestic industry and family life thus presented is very pleasant to dwell upon. Honest John Ruskin, whose heart in matters of political economy is very much better than his logic, may not be quite alone in lamenting the gradual extermination of those rural workers. But lamentations are worse than useless. The system of those days represented but a phase in the history of industrial development, it disappeared to give place to another—it was but transient, as is indeed the system of our own times. Distance is apt to lend here, as elsewhere, enchantment to the view, and it is not unlikely that the workers' lot in those days was, taking all things into consideration, harder than it is now. In 1767 the spinning jenny was invented by Hargraves, and a few years later, Arkwright constructed spinning frames in which were utilised Wyatt's, Paul's, and High's inventions for spinning by rollers. To work these new machines water power was employed, and from this period dates the rise of textile factories. "For several years," says Mr. Redgrave in his report for 1875, "the textile industry was carried on in the rural districts only. . . . . Water on the hill sides was irregular in its flow; work was therefore irregular; when the stream was full, work was brisk (we should have called it excessive); when it was dry the factory hands were employed on the lands in haymaking, or other like occupations. Thus the operatives were both farm labourers as well as factory workers; and as manufacturing was not the complicated affair that it is now, they were free from many evils which afterwards arose from the introduction of steam and the immense energy and enterprise of our manufacturers." The application of steam to the working of machinery created the factory system proper. Inventors had not been idle, and numerous improvements had been effected in several directions. Cartwright had invented his power loom in 1784, and in 1785 Boulton and Watt erected in a factory at Papplewick the first steam engine applied as the moving power for spinning machinery. Progress was now rapid, and in every department of industry invention was producing new improvements. The rising seats of industry had been connected with each other and with the sea by canals. Large steam factories were erected, and, tempted by higher wages and the promise of constant employment, armies of workmen came to fill them from the rural districts. Capital now became a huge power in industry, and very soon occurred the opening skirmishes of the labour war which has continued ever since.

If we are to believe the writers of this period the miseries following upon the introduction of the factory system were very great. In many cases the capitalists made a bad use of their power. "They crowded their factories with apprentices, many of whom they took from the parish with a premium of £5 each. The factories were so unhealthy, and the children worked so hard and for such long hours, as to be seriously injured physically and morally."* In the report already referred to, Mr. Redgrave calls attention to the bringing together, without previously providing adequate and proper means for accommodation, hundreds of families to fill the mills. "Then followed immediately the proneness to run the costly machinery, regardless of the waste of human life, health, and happiness for any number of hours that seemed good to the capitalist. The factory population appeared in time to have become a distinct race that was known at a glance, so defined were the effects of overwork and unhealthy dwellings upon the physical appearance and condition of the people." Nor did the moral condition of the workers improve. Improvident and intemperate, they appeared to go from bad to worse. Due to higher wages and the correspondingly easier conditions of existence, population increased rapidly. While, in fine, an increase of wealth took place in the capitalist part of the community, increase of numbers took place in the operative part. While gold was coined for the master, children were multiplied for his mills.

At a very early period the State had attempted the regulation of industry. In the time of Edward III. there was enacted a Statute of Labourers which attempted to fix the amount of remuneration each labourer should receive. It was intended to keep wages down, but notwithstanding from 1388 to 1444 they rose from 50 to 100 per cent. In the time of Henry VII. there was a law which directed people at what fairs to sell their goods. In the time of Henry VIII. it was made penal to sell any pins but such as are "double-headed and have their head soldered fast to the shank and well smoothed, the shank well shaven, the point well and round-filed and smoothed." During the reign of Edward VI. a statute prescribed that a person making a usurious bargain should be fined £100. In the time of Mary and Elizabeth laws were made limiting the number of looms each master weaver might have, and stating how many more apprentices than journeymen he might employ. In the reign of James I. a very wise Legislature prescribed the quantity of ale which should be sold for a penny.† Laws fixing the rate of interest and the wages of labour, prescribing the price of food and the shape of wearing apparel, specifying the goods to be made and the method of their manufacture were multiplied. In fact, there was in those days scarcely any limit to the duty undertaken by the State. Nor is this surprising when viewed in the true light of history. The citizens had inherited an unlimited belief in the power of government. Primitive tribes could only be successful in war as their soldiers obeyed without question the orders of their chiefs. Those tribes in which the subordination was greatest would accordingly survive, while those in which it was less would in time be weeded out. It was the one necessity of the militant type of society that subordination to the chief should be complete, and faith in him entire. But the general in battle was also ruler during the intervening periods of peace, and to him the people looked to adjust their industrial quarrels, as well as to lead their soldiers to successful battle. Again, "success in war must largely depend on

* Marshall's "Economics of Industry," p. 188.

† See Herbert Spencer's "Social Statics," p. 313.

that conformity to the ruler's will which brings men and money when wanted, and adjusts all conduct to his needs."* Accordingly laws were made just as if industry, like armies, could be governed by force. The discipline of warfare had produced men whose nature it was to submit to control from rulers, and as industrialism grew gradually out of the old militancy, men's natures changed but slowly into adaptation to the conditions of the newer *régime*. Somewhere between savagery and civilisation, partly industrial, partly military, society still believes the ruler all powerful. Every day the Government is petitioned to undertake some new work which it is assumed would be impossible of accomplishment by the community without its aid. Government may change its forms, but the belief in its omnipotent character remains. Savage chiefs may be displaced by emperors and kings. Kings may delegate their functions to Parliaments. Parliaments may, in time, give place to Republican assemblies. But all through history the tradition of unlimited power clings to the rulers, nor will it disappear until man is completely adapted to the social state, and the last sign of militancy shall have disappeared.

I have said that workers became demoralised under the factory system, and appeared to go from bad to worse. Accordingly, the Legislature undertook to set things straight. In 1802 was passed the first Factory Act proper, which directed that "the rooms should be washed well with lime and water twice a year; that apprentices should be clothed with two suits yearly, and should be instructed in reading, writing, and arithmetic the first four years; that the hours of work should not be more than 12 per day, exclusive of meals, and that work might be carried on by night in mills with 1,500 spindles." The rapid development of the steam engine changed the conditions of labour in a short time to such an extent that the Act was no longer applicable, and so, in 1819 and 1825, we have further Acts restricting the hours of labour and the work of children. It may be mentioned that in the textile industries the apprenticeship system had by this time disappeared, as the skill requisite for handling the improved machinery could be attained in a very short time. These Acts were followed in 1831 and 1833 by further Acts relating to textile industries, but in 1834 the Legislature extended its scope, and passed laws influencing other classes of operatives. Accordingly, we soon had Acts of all kinds for the regulation of mines and collieries, print works, bleaching and dye works, bakehouses, copper and iron works, machine shops, fish curing, and fruit preserving. In fact, there are so many Acts that no one knows very well where we stand, and a Factory Enquiry Commission has had to acknowledge that this branch of our laws has become very unwieldy, and wants unification.† That these several enactments made the life of the workers somewhat easier for a time may be true. But that they have produced any true and lasting good, except in so far as they have removed hindrances to the natural growth of industrialism, the student of sociology is at liberty to doubt. And there seemed to be some such doubt in the minds of the workmen themselves, for trades unions, formed at first to petition Parliament to pass measures in their behalf, soon found that the aid they required was not forthcoming, and that they would have to "rely, as the guilds before them had relied, upon their own energies. They no longer approached the Government with the purpose of inducing it to interfere in their behalf; but they petitioned and agitated for the cessation of Government interference against them."‡ The conduct of the trades unions in the early part of the century was reprehensible in the extreme, and the opposition they manifested towards the introduction of machinery is a matter of history. It may, indeed, be doubted if working-men have yet been intellectually convinced of the benefit of machinery. Anyway, they had not been convinced in those days, and labour disputes were oftentimes accompanied by riots and bloodshed. By numerous Acts it had been made a crime punishable by fine and imprisonment to refuse to work for the purpose of obtaining higher wages, and "men who know they are criminals by the mere object they have in view, care little for the additional criminality involved in the means they adopt." However, trades unions have become more sensible, and one by one the combination laws have been repealed. The Legislature now recognises the combination of workmen for the purpose of bettering their condition as perfectly legal, provided that in carrying out their ends nothing is done by the combination which would be declared against law if done by an individual. The trade unions of to-day are in many ways analogous to the craft guilds of the past. They have for their objects, says Mr. Howell—(1) "to procure for their members the best return for their labour in the shape of higher wages, shorter hours of labour, and the enforcement of certain restrictions as to the condition of employment which could not be accomplished except by means of combination; (2) to provide mutual assurance for the members by means of pecuniary assistance in the case of sickness, accident, death, out of work, superannuation when disabled by old age, loss of tools by fire, and emigration.§ These are principles with which no fault can be found, but that they are often very superior to the conduct they are supposed to guide is a matter of everyday observation.

Well, gentlemen, these remarks bring me to modern times. Time has allowed me to notice only a few of the more important factors in the evolution of industrialism. The growth of railways, the development of steam navigation, improvements in agriculture, electric telegraphs, and submarine telegraphy have each made enormous contributions to our industrial progress. But these by no means exhaust the list. It has been said that we of the nineteenth century are intellectually the heirs of all the ages, and not less true is it that present day industrialism inherits a huge legacy from byegone centuries, has grown up by infinitesimal contributions of far away ages, as well as by the larger contributions of recent times. My history has been of a somewhat sketchy character, and the more so, perhaps, as here and there the narrative has been broken in the endeavour to emphasise the method of science in history. To thinking men history is no longer a record of this or that sovereign's deeds, a chronicle of court intrigue, or gossip of princely trappings, but it is the story of a nation's progress. It tells how institutions arise, flourish, and in time decay as new ones take their place. It shows how each successive stage of development arises from the one immediately preceding, and gives birth to the one immediately following it. It recognises that the evolution of society proceeds in accordance with law, and that causation, though partially concealed by the extraordinary complexity of the phenomena to which it relates, must have here, as in all development, universal dominion. And so, as I have said previously, industrialism is a growth, and the present methods of production have been evolved from the processes of the past. We have now huge factories employing thousands of workmen, and filled with self-acting machinery in which the division of labour is carried to the utmost limit. Whereas in times past it was necessary to spend years in serving an apprenticeship and learning several branches of a trade, in a great many instances the old apprenticeship system has been done away with, the whole of a lad's attention when he enters the factory being engaged in watching the one operation performed by an automatic machine. In all branches of the finished metal trades we are struck by the clever combinations of mechanism employed in the performance of the several operations, and as we watch machines rapidly doing their work with unerring precision, and requiring almost no attention, we may well wonder whether economy in production can go much further, whether adjustment of acts to ends can be rendered by mechanism more perfect. In the engineering trades similar division of labour is found and similar specialisation is apparent, though probably to a less extent. When I was an apprentice the old-fashioned millwright was not extinct. He was a man who could "put his hand to anything," as the saying is. He had served seven years' apprenticeship and could make his own patterns, forge whatever he needed, do turning and filing, and, on a pinch, might attempt brass-founding with metal melted over a smith's fire. He was a veritable Jack of all Trades, but he is no more. Modern history does not require him, and draws the line very distinctly between the several branches of the engineering trades. We have smiths who work forging machines and hydraulic press tools. We have turners, planers, slotters, shapers, drillers, millers, and special tool men, each of whom has under his charge an expensive self-acting machine tool which it is his duty to look after and which it should be his aim to thoroughly understand. As Mr. Nasmyth says, "All that the mechanic has to do, and which any lad is able to do, is not to labour, but to watch the beautiful functions of the machine."* In the shipbuilding trades the tendency towards specialisation is not less marked. In short, in every branch of industry the aim is twofold: first, to do as much as possible by machinery because hand labour is expensive; secondly, to restrict the function of the workman to performing one operation or to looking after one machine, because his whole thought being then concentrated on one thing, he soon acquires in his work special dexterity. The effect of the division of labour on the workman, when carried to excess, need not be here considered. On that point opinion is divided, some believing that constant employment, without variety, deadens a man's mental activity and resource, while others, equally capable of judging, hold that concentration on one operation sharpens a man's intelligence so far as concerns the sphere of his work, and gives him more opportunity for thought on subjects unconnected with his employment. However that may be, the division of labour is a great fact in modern industry, and as a means to economical production, there can be no question about its efficacy. The tendency is to carry it farther and farther as concerns, by getting larger, are enabled to take the fullest advantage of the benefit it confers. It is the condition of production which industrialism has by its natural development brought about.

(To be continued.)

* Herbert Spencer, "The Man *v.* The State," p. 109.

† G. Phillips Bevan, "The Industrial Classes and Industrial Statistics." Textiles and Clothing, p. 221.

‡ Marshall's "Economics of Industry," p. 189.

§ "The Conflicts of Capital and Labour," by George Howell, chap. III., section 45.

* Tenth Report of the Trades Union Commissioners, 1868, p. 65

Medical Electricity.—A contemporary says: "Cataphoric medication by electricity has been the subject of experiments by Doctor S. Ehrmann, of Vienna. The following plan is recommended by him in order to facilitate the absorption of the medicated solutions by the skin. Take two similar glass vessels having zinc plates or electrodes for the current at their bottoms. The solution to be absorbed is placed in them, and the hands immersed in it, while the wires of a battery are connected to the plates. The current then circulates from one hand to the other. If a weak solution of methyl blue is used a current of 20 milliamperes is sufficient to cover the hand in the vessel connected to the positive pole of the battery with blue spots, especially on the back."

CORRESPONDENCE.

RULE FOR ELECTRIC BELL AND ALARM WIRING.

To the Editor of The Electrical Engineer.

Sir,—In the fitting of electric bells, signals, fire, and burglar alarms, etc., and more especially in repairs, renewals, or additions thereto, it is of great importance to be able to distinguish "battery wires"—*i.e.*, wires leading direct from or to the battery—from "connecting wires"—*i.e.*, wires running between pushes and indicators, indicators and bells, alarms and bells, etc.

I have devised a rule (see p. 56, "Practical Electrical Notes," second edition, Spon), the adoption of which enables "connecting wires" to be distinguished at a glance from "battery wires"; and, what is more, "+ battery wires" and "– battery wires" are clearly indicated.

My rule is as follows:

"All wires leading from the T pole of the battery to any push, etc., should be of a plain bright colour (say, white, yellow, or red). All wires running between apparatus—connecting wires—should have a covering in which two or more colours are blended, and all wires leading direct back to the battery should be of a plain dark colour (preferably black)."

The adoption of this rule by electric bell fitters would, I beg to suggest, save much valuable time which is now wasted in what is generally termed "testing."—Yours, etc.,

W. Perrem Maycock, A.M.Inst.E.E.

Croydon, Nov. 3, 1890.

LANE FOX CLAIMS.

To the Editor of the Electrical Engineer.

Sir,—At a meeting of the Defence Association, formed to resist the claims being made by the Lane Fox Electrical Company in respect of the Lane Fox patents, held at the offices of the Kensington and Knightsbridge Electric Lighting Company, Limited, at 148, Brompton-road, S.W., the following resolution was passed:

"That the list of members of this association be closed on Saturday fortnight, Nov. 22nd, and after that date members of the electrical trade who, being attacked by the Lane Fox Electrical Company, are desirous of availing themselves of the benefits of this association will be required to pay the double fee of £50." Under these circumstances any members of the trade who wish to join the association should communicate with me before the above-mentioned date.

I may mention, for the benefit of those who are not fully acquainted with the steps that have been taken in the matter, that several opinions have been obtained and submitted to counsel by different members of the association, all of which agree in advising that the claims of the Lane Fox Electrical Company cannot be sustained.

Trusting you will be able to insert this in your next issue, as it is most important that it should reach all your readers.—Yours, etc. (for the Defence Association),

R. S. Erskine, hon. sec.

148, Brompton-road, S.W., Nov. 4, 1890.

ELECTROLYTIC BLEACHING.

To the Editor of the Electrical Engineer.

Sir,—Having read in your last issue the article entitled as above by Mr. Alexander Watt, I beg a portion of your valuable space to correct what I consider the erroneous impression it conveys. Mr. Watt states that electrolytic bleaching "is public property and may be adopted by anyone." This statement by inference seems to apply to any process of electrolytic bleaching, but I must inform Mr. Watt and your readers that if he intends it to apply to Mr. Hermite's well-known process, it is in direct opposition to the opinion of the greatest experts on patent law in this country. The Hermite patents are all in force, and are, I believe, unassailable. Further, Mr. Watt may be interested to know that all he speaks of as being possible to electrolytic bleaching in the future has been done by Mr. Hermite years ago. The Hermite process is working at present in eight large paper mills, in one of which it has replaced over one ton of bleaching powder per 24 hours, working continuously for the past two and a half years.—Yours, etc.,

Charles F. Cooper.

European Works, Dalston, E., Nov. 5, 1890.

To the Editor of The Electrical Engineer.

Sir,—I shall feel thankful if you kindly allow me a little space in your next issue to reply to the extraordinary statements made by Mr. A. Watt, who evidently does not know his subject and has not the remotest idea of electrolytic bleaching. He does not act fairly in representing bleaching by the current as such an easy thing, and in representing his brother as the inventor of the electrolytic decomposition of chloride solutions, and also of the electrolytic bleaching. Electrolytic hypochlorites were known long before 1851, when Charles Watt patented it in England, and when Charles Watt patented the electrolysis of chloride solutions, which he had not invented, it had been patented a few years before by some other English and foreign electricians.

I never say anything which I cannot prove, and Mr. Alexander Watt will find quotations, names, dates, and numbers of patents in my reply to his article.—Yours, etc.,

E. Andreoli.

62, Loughborough-park, S.W., Nov. 3, 1890.

ON THE ELECTROSTATIC FORCE BETWEEN CONDUCTORS CONVEYING STEADY OR TRANSIENT CURRENTS.*

BY DR. OLIVER LODGE.

At the last meeting of the Physical Society this session Mr. Boys described some attempts he had made to detect mechanical force between a pair of Hertz resonators delicately suspended and immersed in a region of electromagnetic waves.

The attempt so far had not been successful; but Mr. Boys, by attending to the energy manifested by Mr. Gregory's method, and by another method of his own, showed good reason why the force, if any, was just too small to be observed even with his extremely delicate appliances, and conjectured that a moderate increase in sensitiveness would be necessary in order to detect the effect.

Everyone must have full confidence that if any such mechanical effect exists Mr. Boys will show it us before long; but, in common with Prof. FitzGerald, I feel provisionally and tentatively doubtful whether any mechanical effect really exists between electric pulses travelling along wires with the velocity of light. In a wire subject to electric stationary waves there are obvious electrostatic pulses at either end and electrokinetic pulses in the middle: but Mr. Boys had allowed for all that, and arranged that the opposing effects of ends and middle should conspire to assist each other in causing rotation. What I felt doubtful about was, whether even in infinite wires, wherein all complication by reflection and stationary waves was avoided, a pair of pulses travelling side by side, like a pair of humps (or a hump and a hollow) on a pair of parallel cords, would exert any force on each other. It is known that two charged bodies flying side by side with the velocity of light will exert no such effect (Mr. Heaviside has shown that this is equivalent to saying that two elements in the same wave-front exert no mechanical force on each other); but whether the same thing is true of two wire-conducted pulses has not, so far as I know, been examined by mathematicians.

If it should turn out that pulses at full speed have no effect, then two straight oscillators in similar phases should repel each other, by the electrostatic effect of the slackening and stationary pulses which are being reflected at the ends.

Such an action seems optically rather interesting. Maxwell predicted that a reflector or absorber would be repelled by light; though, as we know, the complication of the more vigorous molecular action of material surroundings prevented Mr. Crookes from detecting this precise effect. We know, however, that it must exist; and the repulsive effects between alternating magnets and copper discs, detected by Faraday and recently made much of in an interesting manner by Prof. Elihu Thomson, are examples of this very thing. We can even say what the stress caused by full sunshine ought to be—viz., about 50 microbarad †—that is, the weight of half a milligramme per square metre—but it has not yet been experimentally observed. If Mr. Boys finds his effect, at least if he finds it in the form I suggest, as an overbalancing static repulsion, it will represent an action between two sources of light or between two similarly illuminated bodies.

On the afternoon of the meeting of the Physical Society, by Mr. Boys's kindness, I made in a back room a hasty experiment on the

* Paper read before the British Association.

† Langley's recent estimate, that a square centimetre fully exposed to sunshine receives 2·84 C.G.S. thermal units per minute, is equivalent to an energy of 67 ergs per cubic metre of sunshine, or 67 microbarads. (A "barad" means an erg per cubic centimetre, or a dyne per square centimetre.)

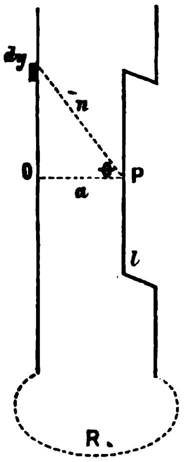
pulses of a Leyden jar discharge, which was passed either in the same or in opposite directions through a pair of flexible parallel strips of aluminium foil, looked at through a microscope.

A fairly distinct effect was observed, its sign being, so far as one could tell, the sign of the electrokinetic effect; *i.e.*, attraction between currents in the same direction, repulsion (more easily observed, because, as it was arranged, nearly four times as strong) between opposing currents. Hence it would seem, so far as this crude observation goes, that pulses in wires do exert their electrodynamic effect. I expected, however, that, by suitably arranging matters, the electrostatic effect of the pulses could be made able to overpower their electromagnetic effect. It is perhaps rather a barbarous plan to consider the two things separately; but until someone attacks the problem in a powerful manner, I have been interested in groping at it, and accordingly make this communication.

First, consider the action of currents in general on each other, and find the ratio between their electrostatic and electrokinetic forces. So far as I know, the electrostatic force between two steady currents is usually overlooked.

No advantage in generality is gained by treating two separate circuits, a movable portion arranged near a fixed portion of one and the same circuit is sufficient.

Arrange a short length, l, at a distance, a, from a long parallel conductor; with a resistance, R, intervening between O and P, the middle opposite points of each; and through the whole send a current, C, up one and down the other.



Then the difference of potential between the two points is R C, or, with alternating currents, P C, where P is the impedance of the wire, R; and if the capacity per unit length of the conductors is called S_1, the linear density of charge on each is on the average $\lambda = S_1 R C$; a little more above O and a little less below it; but unless the distribution of potential differs greatly from a linear distribution, as when l is comparable to a wave-length the mean value will serve.

The electrostatic attraction between the two conductors is

$$F=\int_0^l\int_{-\infty}^{+\infty}\frac{\lambda\, dy\,.\,\lambda' dy'\,.\,\cos\theta}{K r^2}=\int_0^l\int_{-\frac{1}{2}\pi}^{+\frac{1}{2}\pi}\frac{\lambda\, dy\,.\,\lambda'\cos\theta\, d\theta}{K a}$$

$$=\frac{2\lambda\lambda' l}{K a}=\frac{2l}{K a}(S_1 R C)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Unless one of the conductors is very long there is another term, which, however, it is unnecessary to write.

The electrokinetic repulsion between the same conductors is similarly

$$F' = \int\int\frac{\mu C\, dy\, C' dy' \cos\theta}{r^2}=\frac{2\mu l}{a}\,.\,C^2 \quad . \quad . \quad . \quad (2)$$

Steady Currents.

Hence with steady currents the ratio of the static attraction to the magnetic repulsion is

$$\frac{F}{F'}=\frac{S^2 R^2}{\mu K}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

which on every possible system of units is a pure number.

To get a notion of its value, suppose the wires to be round and of radius ρ; then

$$S_1 = K\Big/4\log\frac{a}{\rho};$$

so, remembering that

$$\frac{1}{\mu K}=(\text{the velocity of light})^2=\left(\frac{30 \text{ ohms}}{\mu}\right)^2$$

we see that the above numerical ratio is

$$\frac{F}{F'}=\left\{\frac{\text{number of ohms in the wire R}}{120\log\frac{a}{\rho}}\right\}^2 \quad . \quad . \quad (3')$$

Suppose, for instance, the wires were 50 diameters apart, or $4\log a/\rho = 18{\cdot}4$, the two forces would be equal, and just balance each other, if R was 552 ohms.

With any resistance greater than this the electrostatic force would have the advantage, and two opposite currents in the given wires would attract.

Alternating Currents.

If the current used is an alternating one, impedance must be inserted in (1) and (3) instead of resistance; no other change is necessary. Hence an impedance meter suggests itself. Send a current alternating with given frequency through the pair of conductors joined by the impedance to be measured, and either adjust S_1 until the electrostatic and electrodynamic forces balance, or estimate the outstanding force by a torsion arrangement. Supposing a balance could be got, the impedance of the intervening conductor for the particular frequency implied is

$$P=\frac{1}{S_1\text{ “}v\text{”}}=60\log\frac{a^2}{\rho\rho'} \text{ ohms.}$$

Leyden Jar Discharge.

Next, proceed to consider the transient current of a Leyden jar discharge round the same circuit.

Let a jar of capacity, S, charged to potential, V_0, be discharged round a circuit whose total resistance and inductance are R_0 and L_0 respectively. Then the current at any instant after the discharge has begun is—

$$C = \frac{V_0}{p L_0}e^{-mt}\sin pt; \text{ where } m = \frac{R_0}{2L_0}, \text{ and } m^2 + p^2 = \frac{1}{S L_0}$$

The electrodynamic repulsion between the two wires previously considered, when the discharge occurs, is, therefore, applying (2), an impulse:

$$\phi \quad \frac{2\mu l}{a}\,.\left(\frac{V_0}{p L_0}\right)^2\int_0^\infty e^{-2mt}\,.\,\sin^2 pt\,.\,dt$$

$$=\frac{2\mu l}{a}\,.\,\frac{\frac{1}{2} S V_0^2}{R_0} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

To investigate the electrostatic attraction completely we should have to take into account the sinuous distribution of potential in space over the circuit, but unless the waves are much shorter than usual the ultimate effect on a short length will be very little different from the effect of a uniform potential alternating sinuously in time, the difference of potential at any instant between the fixed and movable wire being

$$V = P C,$$

where P is the impedance of the intervening portion of the circuit.

Hence, the electrostatic impulse is, by (1),

$$\phi \quad \frac{2l}{K a}S_1^2 P^2\int_0^\infty C^2\, dt$$

$$=\frac{2l}{K a}\,.\,\frac{\frac{1}{2} S V_0^2}{R_0}\,.\,S_1^2 P^2. \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

And the ratio of the two impulses is

$$\frac{\phi}{\phi'}=\frac{S_1^2 P^2}{\mu K}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Now $P^2 = p^2 L^2 + R^2$, where $p^2 = \frac{1}{S L_0} - \left(\frac{R_0}{2 L_0}\right)^2$.

So, noticing that $R/R_0 = L/L_0$ as nearly as we please,

$$P^2=\frac{L}{L_0}\left(\frac{L}{S}+\frac{3}{4}R_0^2\right).$$

The second term is frequently negligible, though there is no difficulty in taking it into account if it is not; so the ratio of the impulses at its least is

$$\frac{\phi}{\phi'}=\frac{S_1^2}{K^2}\,.\,\frac{L}{L_0}\,.\,\frac{L/\mu}{S/K} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6')$$

The first of these three numerical factors depends merely on the shape of the acting conductors and their distance apart. The second is a proper fraction which may be made as near unity as we choose. The third involves a comparison between the electromagnetic measure of inductance of the wire included in the circuit, and the electrostatic measure of capacity of the discharged Leyden jar.

Taking as an example the same round wire conductor as before, with

$$S_1=\frac{K}{4\log\frac{a}{\rho}}=\frac{K}{18{\cdot}4}, \text{ say,}$$

and considering $\frac{L}{L_0}$ as $\left(\frac{18{\cdot}4}{20}\right)^2$ for instance, we perceive that the two impulses will be equal and just balance each other if the length representing L on the magnetic system of units be 400 times as great as the length representing S on the electrostatic system. Any wire longer than this gives attraction the advantage; any wire shorter than this favours repulsion.

Or, with different jars discharging round a given circuit, small jars will exhibit the electrostatic impulse, big ones the electrokinetic.

Illustrating numerically still further, a length of 30 metres of No. 16 copper wire opened out into a single large loop has a self-induction of 500 "metres" or 50 micro-secohms. Using this as the wire R between the two suspended conductors, the critical sized Leyden jar which should excite no force when discharged through them is about 1¼ "metres" or ·00014 microfarad—*i.e.*, smaller than the ordinary "pint" size.

With the help of an adjustable condenser, an instrument for measuring the L of well-insulated coils free from iron suggests itself here.

Ribbon Conductors.

If strips are used instead of round wires for the movable conductor, the electrostatic effect has an artificial advantage given it; for take a pair of similar strips of length l, breadth b, and distance apart a, the force caused by a current, C, flowing through them with uniform intensity everywhere is easily calculated to be

$$\frac{4\,C^2\,l\,\mu}{a}\left(\frac{\alpha}{\tan\alpha}+\frac{\log\cos\alpha}{\tan^2\alpha}\right),$$

where α is angle whose tangent is b/a.

The quantity in brackets has a maximum value $\frac{1}{2}$ when α O, i.e., when the plates are far apart enough for their shape to be immaterial; and its value decreases steadily towards zero—viz., $\frac{1}{2}\pi\cot\alpha$, as α approaches 90deg.: the whole becoming ultimately $2\pi\mu C_1 . Cl$.

As for the electrostatic force between strips, I do not know how far we are justified in assuming uniform distribution of density even if given uniform distribution of current; but at least when the plates are close together the force will not be very different from

$$2\pi . \frac{S\,V}{K\,A} . S\,V = \frac{2\,\pi\,l}{K\,b} . (S_1\,P\,C)^2;$$

the value of S_1 being $\frac{K\,b}{4\,\pi\,a}$.

So the ratio of the forces for large close plates is

$$\frac{K}{\mu}\left(\frac{P\,b}{4\,\pi\,a}\right)^2=\left(\frac{\text{No. of ohms in impedance of wire}}{120\,\pi\,a/b}\right)^2.$$

Hence with strips six times as broad as their distance apart the forces will balance for a steady current when the interposed wire is only 60 ohms resistance.

Measure of "v."

In applying an experimental observation of this kind to a determination of the product of the æther constants μ, K (and it just strikes me that it is, after all, only a modification of the method by which Maxwell himself made one of the early determinations), it will be better to use round wires rather than strips, because linear dimensions then come in only under a logarithm, and, moreover, are such as can be measured with considerable accuracy without difficulty. Some of Mr. Boys's quartz-fibre and aluminium tube devices ought to permit the zero of force to be sharply got, and thus a good measure of "v" to be made.

We should have to observe very exactly the neutralisation of all force between the suspended and fixed conductors while a steady current was passing through them, with an interposed wire of known resistance, and then use the relation (3) or (3′) in the form

$$\mu\,K=S_1^2\,R^2,$$

or

$$\text{"}v\text{"}=\frac{S_1}{K}\cdot\frac{R}{\mu}=\frac{\text{resistance of wire expressed as a velocity}}{4\log\frac{a}{\rho}} \qquad (7)$$

If the acting conductors are set very near each other, a being still the distance between their centres, the denominator alters itself a little, becoming—

$$2\log\frac{a^2-2\rho^2+a\sqrt{(a^2-4\rho^2)}}{2\rho^2},$$

with an easy additional complication if it is convenient to make the sectional radii unequal.*

By filling the vessel containing the acting conductors with other insulating media, it is possible that the "v" for them could be directly measured.

(To be continued.)

THE ELECTROMAGNET.†

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

LECTURE II.

(Concluded from page 390.)

GENERAL PRINCIPLES OF DESIGN AND CONSTRUCTION.—PRINCIPLE OF THE MAGNETIC CIRCUIT.

Reference to Table III. shows that if the iron has been magnetised up so as to carry 16,000 magnetic lines per square centimetre, the permeability at that stage is about 320. Iron at that stage conducts magnetic lines 320 times better than air does; or air offers 320 times as much reluctance to magnetic lines as iron (at that stage) does. So then the reluctance in the gaps to magnetisation is 320 times as great as it would have been if the gaps had been filled up with iron. Therefore, if you have the same magnetising coil with the same battery at work, the introduction of air gaps into the magnetic circuit will, as a first effect, have the result of decreasing the number of magnetic lines that flow round the circuit. But this first effect itself produces a second effect. There are fewer magnetic lines going through the iron. Consequently if there were 16,000 lines per square centimetre before, there will now be fewer—say only 12,000 or so. Now refer back to Table III., and you will find that when B is 12,000 the permeability of the iron is not 320, but 1,400 or so. That is to say, at this stage, when the magnetisation of the iron has been pushed only so far, the magnetic reluctance of air is 1,400 times greater than that of iron, so that there is a still greater relative throttling of the magnetic circuit by the reluctance so offered by the air gaps.

Apply that to the case of an actual electromagnet. Here is a diagram, Fig. 31, representing a horseshoe electromagnet with an armature of equal section in contact with it. The actual electromagnet for the experiment is here on the table. You can calculate

FIG. 31.—Electromagnet with Armature in Contact.

out from the section, the length of iron, and the table of permeability, how many ampere-turns of excitation will produce any required pull. But now consider that same electromagnet, as in Fig. 32, with a small air gap between the armature and the polar faces. The same circulation of current will not now give you as much magnetism as before, because you have interposed air gaps; and by the very fact of putting in reluctance there, the number of magnetic lines is reduced.

Try, if you like, to interpret this in the old way by the old notion of poles. The electromagnet has two poles, and these excite induced poles in the opposite surface of the armature, resulting in attraction. If you double the distance from the pole to the iron, the magnetic force (always supposing the poles are mere points) will be one quarter; hence, the induced pole on the armature will only be one quarter as strong. But the pole of the electromagnet is itself weaker. How much weaker? The law of inverse squares does not give you the slightest clue to this all-important fact. If you cannot say how much weaker the primary pole is, neither can you say how much weaker the induced pole will be, for the latter depends upon the former. The law of inverse squares in a case like this is absolutely misleading.

FIG. 32.—Electromagnet with Air Gaps One Millimetre Wide.

Moreover, a third effect comes in. Not only do you cut down the magnetism by making an air gap, but you have a new consideration to take into account. Because the magnetic lines, as they pass up through one of the air gaps along the armature, down the air gap at the other end, encounter a considerable reluctance, the whole of the magnetic lines will not go that way. A lot of them will take some shorter cut, although it may be all through air, and you will have some leakage across from limb to limb. I do not say you never have leakage under other circumstances. Even with an armature in apparent contact there is always a certain amount of sideway leakage. It depends on the goodness of the contact; and if you widen the air gaps still further you will

* See Foster and Lodge, *Phil. Mag.*, June, 1875, p. 456.

† Cantor lectures, delivered before the Society of Arts.

have still more reluctance in the path, and still less magnetism, and still more leakage. Fig. 33 roughly indicates this further stage. The armature will be far less strongly pulled, because, in the first place, the increased reluctance strangles the flow of magnetic lines, so that there are fewer of them in the magnetic circuit, and, in the second place, of this lesser number only a fraction reach the armature because of the increased leakage. When you take the armature entirely away, the only magnetic lines that go through the iron are those that flow by leakage across the air from the one limb to the other. This is roughly illustrated by Fig. 34, the last of this set.

Leakage across from limb to limb is always a waste of the magnetic lines, so far as useful purposes are concerned. Therefore it is clear that, in order to study the effect of introducing the distance between the armature and the magnet, we have to take into account the leakage; and to calculate the leakage, is no easy matter. There are so many considerations that occur as to that which one has to take into account, that it is not easy to choose the right ones and leave the wrong ones. Calculations we must make by-and-by—they will be added as an appendix to this lecture, but for the moment experiment seems to be the best guide.

I will therefore refer, by way of illustrating this question of leakage, to some experiments made by Sturgeon. Sturgeon had a long tubular electromagnet made of a piece of old musket barrel of iron wound with a coil; he put a compass needle about a foot away, and observed the effect. He found the compass needle deflected about 23deg.; then he got a rod of iron of equal length and put it in at the end, and found that putting it in so that only the end was introduced—in the manner I am now illustrating to you on the table—the deflection increased from 23deg. to 37deg.; but when he pushed the iron right home into the gun barrel it went back to nearly 23deg. How do you account for that? He had unconsciously increased its facility for leakage when he lengthened out the iron core. And when he pushed the rod right home into the barrel, the extra leakage which was due to the added surface could not and did not occur. There was additional cross-section, but what of that? The additional cross-section is practically of no account. You want to force the magnetism across some 20in. of air which resists from 300 to 1,000 times as much as iron. What is the use of doubling the section of the iron? You want to reduce the air reluctance, and you have not reduced the air by putting a core into the tube.

FIG. 33.

There is a paradoxical experiment, which we will try next week, that illustrates an important principle. If you take a tubular electromagnet and put little pieces of iron into the ends of the iron tube that serves as core, and then magnetise it, the little pieces of iron will try to push themselves out. There is always a tendency to try and increase the completeness of the magnetic circuit; the circuit tends to rearrange itself so as to make it easier for the magnetic lines to go round.

Here is another paradoxical experiment. I have here a bar electromagnet, which we will connect to the wires that bring the exciting current. In front of it, and at a distance from one end of the iron core, is a small compass needle with a feather attached to it as a visible indicator, so that when we turn on the current the electromagnet will act on the needle, and you will see the feather turn round. It is acting there at a certain distance. The magnetising force is mainly spent not to drive magnetism round a circuit of iron, but to force it through the air, flowing from one end of the iron core out into the air, passing by the compass needle, and streaming round again, invisible, into the other end of the iron core. It ought to increase the flow if we can in any way aid the magnetic lines to flow through the air. How can I aid this flow? By putting on something at the other end to help the magnetic lines to get back home. Here is a flat piece of iron. Putting it on here at the hinder end of the core ought to help the flow of magnetic lines. You see that the feather makes a rather larger excursion. Taking away the piece of iron diminishes the effect. So, also, in experiments on tractive power, it can be proved that the adding of a mass of iron at the far end of a straight electromagnet greatly increases the pulling power at the end that you are working with; while, on the other hand, putting the same piece of iron on the front end as a pole-piece greatly diminishes the pull. Here, clamped to the table, is a bar electromagnet excited by the current; and here is a small piece of iron attached to a spring balance, by means of which I can measure the pull required to detach it. With the current which I am employing the pull is about 2½lb. I now place upon the front end of the core this block of wrought iron; it is itself strongly held on, but the pull which it itself exerts on the small piece of iron is small. Less than half a pound suffices to detach it. I now remove the iron block from the front end of the core, and place it upon the hinder end. And now I find that the force required to detach the small piece of iron from the front end is about 3½lb., instead of 2½lb. The front end exerts a bigger pull when there is a mass of iron attached to the hinder end. Why? The whole iron core, including its front end, becomes more highly magnetised, because there is now a better way for the magnetic lines to emerge at the other end and come round to this. In short, we have diminished the magnetic reluctance of the air part of the magnetic circuit, and the flow of magnetic lines in the whole magnetic circuit is thereby improved. So it was also when the mass of iron was placed across the front end of the core; but the magnetic lines streamed away backwards from its edges, and few were left in front to act upon the small bit of iron. So the law of magnetic circuit action explains this anomalous behaviour.

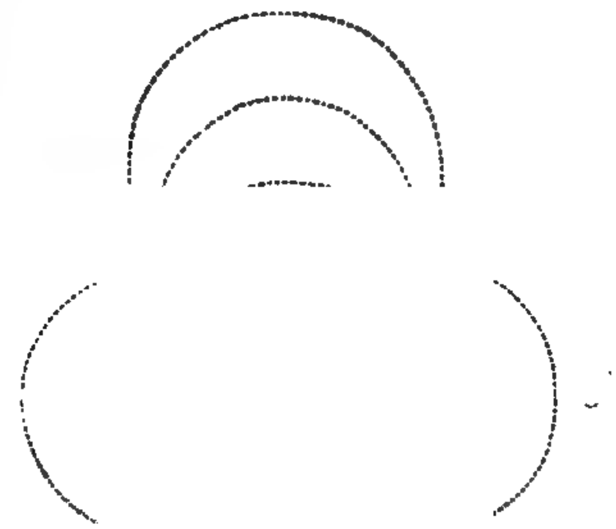


FIG. 34.

Facts like these have been well known for a long time to those who have studied electromagnets. In Sturgeon's book there is a remark that bar magnets pull better if they are armed with a mass of iron at the distant end, though Sturgeon did not see what we now know to be the explanation of it. The device of fastening a mass of iron to one end of an electromagnet in order to increase the magnetic power of the other end was patented by Siemens in 1862.

COMPANIES' MEETINGS.

WESTMINSTER ELECTRIC SUPPLY CORPORATION.

The third ordinary general meeting of the shareholders of this Company was held at the offices, 32, Victoria-street, S.W., on Wednesday, Lord Suffield in the chair.

The **Secretary** (Mr. Frank Iago) read the notice convening the meeting, together with the minutes of the last (extraordinary) meeting, which latter were confirmed.

The report of the Directors, which was published in our last issue, was taken as read.

The **Chairman** said that he need not detain them long as he had not a great deal to say beyond what the meeting already knew from the report and the maps on the walls of the room, which showed the progress that had been made. Prof. Kennedy, he was sure, would be happy to give any explanation to anybody wishing it. Since those maps were made further progress had taken place, nearly 11¾ miles of mains had been completed. There had been trouble and delay, partly from necessary causes and partly otherwise, not on their part, but on the part of those with whom they

had had to deal with respect to obtaining sites for stations. He congratulated himself and them on the great progress that had been made during the time at their disposal. They had already a station at Millbank-street, which was in working order, and he gave great credit to their chief engineer for the extraordinary ability and energy he had shown. That station was now giving current even as far as the spot marked on the bottom of the map on the wall. Their other works were also in progress. They had completed the excavations in Davies-street, and they would be proceeding with the concrete foundations for the engines almost immediately, and a considerable portion of the necessary plant was not only ordered but ready to be delivered. The works in Eccleston-place were also proceeding, and, in fact, although they were not in a position to supply current to any great extent at present, he hoped that before long they would be able to do so. Everything was progressing satisfactorily. It was Prof. Kennedy's wish that he should say that any shareholder who felt so disposed could go and see the Millbank station; they would then be able to form their own opinion as to the kind of work that had been done. The Directors and himself had worked hard in the shareholders' interest and their own. He would invite questions, which he would be delighted to answer.

A **Shareholder** asked if applications for current were numerous.

The **Chairman** said: Yes; they came in every day. They could not, of course, supply them all at present, but some would be supplied in December, and the greater portion—in fact, nearly all—in the early part of January. In answer to another question, he said that application to the Stock Exchange for a settlement had been made and granted.

Mr. Frankenstein asked: 1. When would the remainder of the capital be called up? 2. What prospect was there of a dividend? 3. Had they a monopoly of the lighting in the district mentioned in the report.

The **Chairman** answered: 1. It was impossible to say. But he supposed they would have to make another call early next year, but when the whole of the capital would be called up he was not in a position to state. 2. They had so much to do that they must not expect an early dividend. 3. They had not an absolute monopoly. They had a monopoly in part of the district, but not throughout the whole. There would always be a rivalry between certain companies, and it would be for them (the Westminster) to ensure such perfection in their arrangements as would give them a fair start. They were the only Company supplying on that particular system, and they considered it the best, and hoped that consumers would think so also. One important point in their system was that in taking on new customers they had not to cut off the current from any other wires. Other companies had to cut off their whole circuit to supply a customer. The only company in competition with them was the London.

Mr. Scott, speaking from a shareholder's point of view, thought they must give the Board time to carry out important work of that kind. With regard to competition, he always understood that Parliament had given them the half of that district, along with the London Company, and if they (the Westminster) did their duty reasonably, the Board of Trade would maintain them in their position. He would like to say that, having had an opportunity of going over the works on Tuesday, he was quite astonished to find the progress which the Directors had made in providing for the lighting of the district. The station near the House of Commons was in a very forward condition, and, in fact, was working when he was there. In a day or two that station would be in full work, and the House of Commons would be lighted from it instead of the temporary iron shed hitherto used. The other two stations showed considerable progress, especially that at Eccleston-square, which, with the open weather they were having, would make a grand show before Christmas. The excavations for the station near Oxford-street, though only taken in hand in September, had gone on rapidly, and they were putting the concrete in now. When these stations were ready they would not stand waiting for their machinery, for it was ordered, and in some cases ready. It appeared to him that within a year from the formation of the Company the work would be got on with to a degree that he never expected. With regard to a dividend, he had heard indirectly that a neighbouring company were going to show a very good one at their coming meeting. It had been at work a few months longer than they had. Turning to another point which concerned the Directors, he said that the articles of association were made at an early date before the Company had assumed its present proportions and its present capital. The article dealing with Directors' remuneration said it should be £200 for the Chairman and £100 for the others, and such other sum as should be voted in general meeting. The Directors had been working most heartily and successfully, and he did not think the article mentioned an adequate sum. He would like to suggest that the Board should at an early opportunity call a statutory meeting at which to alter that article, for he understood that they had taken no remuneration whatever at present. They did not want their Directors to work for nothing, and he for one, as representing perhaps the largest interests in the Company, was quite prepared to say that the Directors should be properly paid, and they had not prompted him to say this. He congratulated the shareholders on the position they occupied, it appeared to him that the Company was going rapidly on to success. He spoke as a man of business, not as an electrician.

Mr. Stuart asked the engineer whether the expenditure already made exceeded the estimates made on the formation of the Company, and was the Board of opinion that the capital was adequate to carry out what was intended?

Prof. Kennedy said the expenditure up to then had been well within all the estimates that he had submitted, and

The **Chairman** replied that the capital was quite adequate (he did not know what they might be induced to do later on) for what they had before them.

In reply to **Mr. F. A. White**, who asked whether the expenditure outside the engineer's estimates had been within the limits,

The **Chairman** said, with regard to sites they were quite unable to judge what that would come to, but they considered they had been within what the Board thought right. They saw every probability, when they were in full work, of making a very good dividend.

Prof. Kennedy having explained from the maps on the walls what had been done as far as engineering work went,

A **Shareholder** asked if all the shares had been taken up, and it was explained that of the 60,000 shares 40,000 odd were taken up by the public, and it was agreed to withdraw the balance.

In answer to another question as to the danger of using the electric light, **Prof. Kennedy** explained that the Company's system was a low-tension one, and was undoubtedly not dangerous; nobody could get seriously hurt.

The adoption of the report was moved by the **Chairman**, seconded by **Mr. Boulnois, M.P.**, and carried *nem. dis.*

Votes of thanks were passed to the Chairman and Directors, Prof. Kennedy, the General Manager, and the staff.

MONTE VIDEO TELEPHONE.

The annual ordinary general meeting of the shareholders of this Company was held on Friday, at the offices of the Company, 25, Abchurch-lane, E.C., Mr. Arthur Holland presiding.

The **Chairman**, in moving the adoption of the report, said that, considering the wave of depression which had passed over both sides of the River Plate, both at Monte Video and Buenos Ayres, it was not an unsatisfactory one, as they had practically the same profit this year as last. After making deductions for preliminary expenses, depreciation, etc., the profit amounted to £10,494, and they proposed that the full dividend of 6 per cent. be declared on the preferred shares, and of the balance that £1,000 should be carried to the reserve fund. He pointed out that they had spent on capital expenditure £5,600 during the past twelve months for the purpose of extending their wires and cables. In the profit and loss account there was an increase in the subscriptions of £891, and an increase in the expenditure in Monte Video of £1,120. They must wait patiently for things to improve in Monte Video, and he felt confident that the ordinary shares, in a year or two, would become very valuable property. If they had not had large withdrawals of their subscribers this year, and had continued in the normal state with the additions they had received of new subscribers, they should have been able to pay a dividend of 6 per cent. on the ordinary stock. He then formally proposed the adoption of the report and accounts, which was seconded by **Mr. T. D. Peters**, and agreed to.

The **Chairman** then proposed that a dividend of 6 per cent. on the preference shares, as recommended, be paid, and that £1,000 be placed to the reserve fund.

Both motions, having been seconded, were carried unanimously, and the proceedings terminated with a vote of thanks to the Chairman and Directors.

NEW COMPANIES REGISTERED.

United Alkali Company, Limited.—Registered by H. Forshaw and Hawkins, 5, Castle-street, Liverpool, with a capital of £6,000,000 in 300,000 preference and 300,000 ordinary shares of £10 each. Among the very comprehensive objects of this Company we notice that they intend to carry on any business directly or indirectly connected with the generation, accumulation, distribution, supply, or application of electricity, besides the business of chemical manufacture, salt manufacture, paint manufacture, dye manufacture, sanitary and disinfecting manufacture, etc. The first subscribers are:

	Shares.
J. Brock, Widnes	1
H. Gaskell, Widnes	1
J. K. Huntley, Flint	1
C. Wigg, Liverpool	1
J. H. Dennis, Liverpool	1
A. W. Allhusen, Gateshead, Durham	1
J. E. Davidson, Newcastle-upon-Tyne	1
C. E. Barlow, Widnes	1
J. C. Stevenson, M.P., South Shields	1
J. Tennant, Saltwell, Gateshead	1
G. L. Wigg, Runcorn	1
P. J. Worsley, Bristol	1
J. A. Rayner, St. Helens	1
E. K. Muspratt, Dale-street, Liverpool	1
W. J. Menzies, St. Helens	1
H. Gaskell, jun., Widnes	1
R. Shaw, Widnes	1

Sir C. Tennant, Bart., shall be the first honorary president, and Sir Edward Sullivan, Bart., Holbrook Gaskell, John K. Huntley, and J. Hawke Dennis, vice-presidents. The qualification of every such officer shall be the holding of £5,000 shares in the Company. These honorary officers shall *ex-officio* be Directors of the Company. Until otherwise determined, there shall not be less than 9 nor more than 20 Directors, exclusive of the *ex-officio* Directors above-mentioned, and exclusive of managing Directors.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the week ended October 31 amounted to £5,411.

Great Northern Telegraph Company.—The receipts for October were £26,000, making, from January 1, a total of £232,800.

Cuba Submarine Telegraph Company.—For the month of October the receipts show an increase of £297, as compared with the corresponding period.

Direct Spanish Telegraph Company.—For the month of October the receipts show an increase of £154, as compared with the corresponding period.

West India and Panama Telegraph Company.—The receipts for the half-month ended October 31 show an increase of £175 as compared with the corresponding period.

Eastern Telegraph Company.—The traffic receipts of the Company for October were £59,589, as against £62,981 for the same period of 1889, or a decrease of £3,392.

Eastern Extension Telegraph Company.—The receipts of the Company for October amounted to £47,117, as against £45,679 in the corresponding period, showing an increase of £1,438.

Middlesbrough Electric Light Company.—Certificates for this Company are now ready, and will be exchanged for banker's receipts at the London office, Blomfield House, New Broad-street, E.C.

Elmore's French Patent Copper Company.—It is announced that M. Eugene Secretan, of Paris, the late managing director of the Société de Metaux, has been appointed general manager in France of this Company. Application has been made to the Stock Exchange to appoint a settling day and quotation for the shares.

West India and Panama Telegraph Company.—The report of this Company for the half-year ended June 30 shows an available balance of £24,698, out of which it is proposed to pay the first preference dividend, for six months to June 30, of 6s. per share, and the second preference dividend, on account of arrears to June 30, of £3 per share, the balance to be carried over being £322.

Western and Brazilian Telegraph Company.—The Board have decided that after placing £7,500 to the renewal fund, and £5,280 to the debenture redemption fund, the Directors would recommend, at the forthcoming meeting, a dividend of 6s. per share (free of income tax), being at the rate of £4 per cent. per annum, for the six months ended June 30 last. The receipts of the Company for the week ended Occtober 31, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,235.

Metropolitan Electric Supply Company.—The report of the Directors states that under the Electric Lighting Act it has been provided that the accounts of statutory supply companies shall be made up to the 31st of December in each year. In order to comply with this requirement it is necessary to alter the period of the Company's financial year to the end of December, and the date of the annual general meeting to the beginning of next year. The accounts for the 15 months ending the 31st of December next will therefore be submitted to the meeting to be held early in 1891. The Company is making steady and substantial progress in its works, and what promises to be a large and remunerative business is being built up. During the 14 months which have elapsed since the Company obtained parliamentary powers upwards of 40 miles of electric light mains have been laid in pipes under the streets of the principal thoroughfares of the Company's districts. Current is being supplied from four central stations, two of which—viz., Whitehall and Sardinia-street—are fully equipped, while the other two—viz., Rathbone-place and Manchester-square—are on the eve of completion. The Company's area of supply has been enlarged by the addition of the important and valuable district of Paddington. While it is impossible, until the accounts have been made up and audited, to review the Company's financial position in detail, the Directors are of opinion that the prospects of the Company are such as to warrant them in looking forward to a satisfactory dividend being earned during the ensuing year.

PROVISIONAL PATENTS, 1890.

October 27.

17165. **A process for producing copper blocks with steel core, for the manufacture of telegraph and telephone wire.** Heinrich Lohausen, Temple-chambers, London.

October 28.

17181. **Improved electric switch.** Herbert John Allison, 52, Chancery-lane, London. (John Alexander Kennedy McGregor, Henry Wallach, and Solomon J. Wallach, United States.) (Complete specification.)

17247. **Improvements in electric apparatus for transmitting motion.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

17266. **Improvements in electric railways.** John Corry Fell, 1, Queen Victoria-street, London. (Charles Richter, United States.)

October 29.

17277. **An improved method of and apparatus for the electrical treatment of sewage, wines, oils, air, gases, and other fluids.** Robert Wotherspoon, 62, St. Vincent-street, Glasgow. (Henry Rowley, Australia.)

17308. **Improved switch for electric light.** Charles Walter Cox and Frederick Robinson, 8, Strand-street, Liverpool.

17309. **An improved method of lighting ship's side, mast head, and signal lamps by electric light.** Charles Walter Cox, Frederick Robinson, and William Henry Gritton, 8, Strand-street, Liverpool.

17322. **Improvements in telephones.** Eugen Hartmann and Wunibald Braun, 47, Lincoln's-inn-fields, London.

17327. **An improved electric meter.** Herbert Woodville Miller, 28, Southampton-buildings, London. (Complete specification.)

October 30.

17335. **Improvements in electric motors.** Frederick B. Fawcett, Torpels, Weston-super-Mare.

17366. **The application of electricity by or through boots, shoes, slippers, and such like to the human body.** William Mannion and James Hewitt, 148, St. Saviour's-road, Leicester.

17375. **An electric motor.** J. B. Denis, 54, Dean-street, Soho, London.

17379. **Improvements in coding and transmitting telegrams and secret messages.** Samuel Joseph Mackie, 27, Chancery-lane, London.

17394. **Apparatus for effecting a permanent make or break of an ele·tric circuit at any suitable number of points.** Lucien Vialet Chabrand, 46, Lincoln's-inn-fields, London.

October 31.

17402. **Improvements in and connected with electrical conductors, and fittings combined therewith.** David Cook, Carrington Riddell Gordon Smyth, and Ernest Payne, 140, Bath-street, Glasgow.

17444. **An improved filling for galvanic batteries.** Max Müthel, 115, Cannon-street, London.

17459. **Improvements in and relating to electric arc lamps.** Frédéric Victor Maquaire, 45, Southampton-buildings, London.

17488. **Pivoted lamp posts for electric lighting.** John Alfred Radley, 14, Thorpe-road, Norwich.

November 1.

17532. **Improvements in electric motors.** James Collins, 47, Lincoln's-inn-fields, London.

17558. **Portable generator and electrometer for testing insulation of electric wires.** John James Rathbone, 166, Fleet-street, London.

17560. **Improvements in and relating to locked switches for electric current circuits.** John Abbott Iliffe and Henry Barton, 433, Fleet-street, London.

SPECIFICATIONS PUBLISHED.

1889.

15733. **Electrical signalling apparatus.** Ducretet. 8d.

17819. **Electric switches.** Slatter and Rixon. 8d.

17915. **Telegraph circuits.** Gisborne (Keeley). 8d.

19081. **Microtelephonic apparatus for drivers.** Wreden. 8d.

19829. **Phonographs.** Mills (Edison). 8d.

1890.

6041. **Transformation of ele trical energy.** Dewey. 8d.

10595. **Measuring electrical energy.** Thomson. 1s. 3d.

12228. **Dynamo-electric machines.** Easton. 6d.

12979. **Thermo-electric generators.** Cox. 8d.

13002. **Induction coils.** Lake (Thomson). 8d.

13003. **Electrodes.** Pepper. 6d.

13024. **Electrolysis of melted haloid salts.** Rennerfelt. 4d.

13233. **Portable electric lamps.** The Mining and General Electric Lamp Company, Limited, and Moscrop. 6d.

13780. **Electric conduits.** Elliott. 8d.

13905. **Electric welding.** Dewey. 8d.

13906. **Electric welding.** Dewey. 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2½
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	8

NOTES.

Newport (Mon.).—The Town Council will apply for an order.

West Hartlepool.—The Town Council have decided to apply for an order.

The Cardiff County Council have appointed a lighting and electric committee.

Electric Lighting in Austria.—A central station is to be proceeded with at Sternberg.

Ship Lighting.—H.M.S. "Terpsichore" was launched a few days since. She will be lighted electrically.

Coblentz.—The telephone line between Coblentz and Cologne will be finished before the end of the year.

Dijon (France).—A telephone exchange was opened here on the 1st inst. It starts with 99 subscribers.

The Telephone in Sweden.—The Telephonic Administration in Sweden is buying up outside companies.

Train Lighting.—Trials have been made at Berlin with 8-c.p. lamps fed by accumulators for train lighting.

City and South London Railway.—It is stated that this railway will be opened to the public on the 26th inst.

Waterford. — We understand that Messrs. Laing, Wharton, and Down have been reorganising their station here.

Eastbourne.—The telephone company have reduced the rent of the fire brigade telephones from £91 to £80 per annum.

Oldbury.—The Local Board have refused their sanction to Messrs. Latimer Clark, Muirhead, and Co.'s applying for an order.

Last Week's Gale.—The high wind on Thursday and Friday in last week caused the usual havoc among overhead wires in town.

Kingston-on-Thames.—The Town Council has decided to apply for an order with a view to keeping out supply companies.

New Ross (Ireland).—Mr. Arthur F. Guy was to give a lecture on electricity to the New Ross Town Commissioners last (Thursday) night.

Overhead Wires.—The Highways Committee of the North Riding (Yorks.) County Council are considering the question of overhead wires.

Proposed Tramway.—Mr. Chadwell has submitted plans to the Oswaldtwistle Local Board for an electric tramway from that town to Accrington.

Sutton (Surrey).—Mr. Holford's scheme for providing, *inter alia*, an electric light station at Sutton has been practically shelved by the Local Board.

Vienna.—The installation at the Gesellschaft der Musikfreunde here will soon be completed, and the trial run is expected to take place shortly.

Bromley (Kent).—The Local Board have determined to apply for an order. We understand that Prof. Kennedy has been called in as professional adviser.

Preston (Lancs.).—The National Electric Supply Company have put up a few lights in Fishergate temporarily with the sanction of the Town Council.

Consett.—The Local Board charge the National Telephone Co. 1s. for every pole erected. The company are completing their line between Newcastle and Consett.

Aylesbury.—Messrs. Latimer Clark, Muirhead, and Co. have asked for the Local Board's sanction to their applying for an order. The matter has been adjourned.

Stettin.—Messrs. E. Buchholz and Co., of this town, have the work of lighting Herr J. Bobrisch's brewery with electric light. Seven arcs and 200 incandescents will be used.

A French Battery Company.—The Compagnie Française des Piles Universelles has been founded in Paris by MM. Paul Oudin and H. Othon Kratz. The office is at 3, Rue Saint-Laurent.

Breslau.—The *Electrotechnische Zeitschrift* says that the building of the central station here is progressing so rapidly that it is expected the management will be able to take possession of it in February next.

The Telephone in Austria.—It is proposed to establish a network of telephone lines between a large number of towns in Northern Bohemia, and to connect these with the exchange at Prague.

Another Ship Fire.—Mrs. Stanley appears to have had a bad passage to New York; among the other *désagrémens* being a small blaze, due to the electric light leads. This was on the "Teutonic."

Society of Arts.—Mr. F. Bailey's paper on "Electric Lighting Progress in London" is down for December 10th. The presidential address will be delivered on the 19th inst. at 8 p.m., by Sir Richard Webster, M.P.

Personal.—A full length portrait of Mr. T. Parker, of the Electric Construction Corporation, has been hung in the Wolverhampton Art Gallery. It has been painted by Mr. E. Goodwyn Lewis for Mr. James Oddie, of Ballarat.

Chiswick.—The Local Board will apply for an order. The West Metropolitan Electric Light Co. have offered to contract for supplying current, but the Board do not seem inclined to consider the matter yet, and it has been labelled "premature."

The Paris (1889) Exhibition.—The delay which has taken place in the distribution of the medals and diplomas awarded at this exhibition, is said to have been due to the care with which the latter have been produced. They are to be distributed shortly.

Watchmen's Tell-Tale Checks.—The Sussex County Lunatic Asylum is being fitted with a system of electric tell-tale checks, which will enable those in authority to detect anything amiss on the part of those who have to supervise the wards by night.

The German Exhibition.—The first meeting of the German Honorary Advisory Council of the forthcoming German Exhibition in London was held a few days ago at the Deutsche Bank, George-yard, Lombard-street, City, under the presidency of Mr. O. von Ernsthausen.

Underground Mains.—The Strand Board of Works have discussed the question of subways for underground electric mains, gas and water pipes, and the matter has been referred to the Works and Parliamentary Committee with a view to getting other authorities to combine in this direction.

North-East Coast Institution of Engineers.—The papers to be read before this institution during the ensuing (seventh) session include one by Mr. W. C. Mountain on "Electrical Engineering." It is down for the 9th of March. The president this session is Mr. Wigham Richardson.

Telephone Line between Vienna and Brunn.—The line between these two towns was to be opened for use on the 1st inst. The wires are of bronze. This new line will prove a great convenience to subscribers to the exchanges in Brünn and Vienna, who will now be in direct communication.

Glue for Indiarubber.—Dissolve one part of gum lac in 10 parts of ammonia. The resulting mass is transparent, but will not become liquefied for three weeks or a month. It cannot be employed till then, but after this period will glue rubber to rubber or rubber to metal.—*Révue Industrielle.*

Cyanides and Tuberculosis.—According to a Viennese chemist, who for several years was employed in silvering and gilding works the atmosphere of which was always charged with cyanhydric acid vapour, several workmen, afflicted with consumption when they entered the works, were cured by the inhalation of the vapour.

Telegraph Material Wanted.—The Cheshire Lines Committee are asking for tenders for the supply of telegraph instruments, wire, and other materials. Further information can be had of Mr. S. S. Barton, storekeeper, Cheshire Lines, Warrington. Tenders are to be in the hands of Mr. Edward Ross, secretary, London-road Station, Manchester, by 10 a.m. on the 29th instant.

Lord Mayor's Day.—At the Guildhall banquet on Monday evening last the large dining-hall was lighted by about 500 incandescents fixed to the gasoliers above the tables, and the effect produced was much admired. The work was carried out by the Brush Electrical Engineering Company at very short notice, and they are therefore the more to be congratulated on the happy result.

The Taunton Accident.—Among those injured in the accident to the G.W.R. express from Plymouth to London with passengers from the Cape early on Tuesday morning, was a Mr. Hall, who described himself as an electrician, connected with the De Beer mines. Mr. Hall, who was in the second compartment of the first carriage, seems to have had a marvellous escape from death.

Leamington.—The Corporation are applying for an order as well as Messrs. Chamberlain and Hookham. The town clerk has been instructed not to pay the lighting account, and Messrs. Chamberlain and Hookham demand 5 per cent. on the unpaid account, and have given the Corporation six months' notice to terminate the contract. They dispute the borough surveyor's photometric tests.

Loss of H.M.S. "Serpent."—With reference to the wreck of H.M.S. "Serpent" on the coast of Galicia, we notice that a daily paper thinks the disaster may possibly be due to disturbance of the ship's compasses caused by the mineral character of the land in this neighbourhood. It is within the bounds of possibility, but we should be more inclined to think that a breakdown in the machinery was the immediate cause of the regrettable occurrence.

Copenhagen.—Messrs. Siemens and Halske have been entrusted with the work of erecting a central station here for the town authorities. It will be of sufficient capacity to feed 14,000 lamps. The work will be taken in hand in the coming spring, so that the lighting may be ready by the time winter sets in next year. The three-wire system will be adopted. During the day the lighting current will be supplied by Tudor accumulators, giving a discharge of 250 amperes.

Paris Lighting.—The electric companies in Paris are protesting against the agreement between the Municipal Council and the Paris Gas Company, whereby the latter are to be authorised to supply electricity. The above Council have passed a resolution that Parliament ought to assimilate the production of electricity for lighting purposes with those industries considered dangerous. This is with a view to installations being closely inspected by the Prefecture of Police! The Council are also crusading against the emission of smoke by central stations.

Woking.—The installation at Woking has been completed, and was working this week. The plant consists of two multitubular boilers of 100 h.p. each, working at a pressure of 150lb., and two high-speed triple-expansion engines, each driving a dynamo capable of supplying 2,000 eight-c.p. incandescent lamps. The price charged is 8d. per unit. There is room at the station for doubling the plant should the demand for the light warrant it. Hitherto, Woking has had no illuminant other than oil and candles, and there is no system of public lighting whatever.

Chagford (Devon).—There is a possibility of the electric light being introduced into Chagford. Mr. G. H. Reed, millwright and machinist, has leased part of a woollen factory there, and last week gave a demonstration with incandescent lights, fed by a Joel dynamo. Mr. Eaton, of London, subsequently addressed a meeting at which he expressed surprise that with gas at 6s. 8d. per 1,000 the electric light had not been introduced before. Mr. McSweeney, electrical engineer, also gave a lecture on electricity. A canvass of the town is said to have resulted favourably for electric lighting.

Croydon.—As will be seen from another column, Mr. Preece has presented a report to the Croydon Town Council on the proposed lighting of the borough by electricity. He recommends a high-pressure system with transformer stations, owing to the scattered nature of the area to be supplied. He thinks that the Council need not anticipate having to supply more than 6,400 lamps during the first two years—viz., 3,400 public and 3,000 private lamps—and that to do this £50,000 capital will suffice. Having considered the report the Council have decided to apply for an order.

The Lane Fox Patents.—From an advertisement in our columns and from other sources we gather that the only claim which the Lane Fox Electrical Company have wished to enforce, so far, is that based on Mr. Lane Fox's leading patent, No. 3,988**, of 1878. Their motives having been misunderstood, however, they have determined to anticipate any attempts to evade their claims by enforcing that based upon patent No. 4,726, of 1878, for the use in connection with their system of shunt electrometers—*i.e.*, of the class of instruments known as voltmeters or potential electrometers, with or without automatic attachments.

The Telephone in France.—Inter-urban conversations at night—that is, between 9 p.m. and 9 a.m.—are proposed to be charged as follows: Ordinary conversations, lasting five minutes, 30 centimes per 100 kilom., or fraction thereof. To subscribers of more than one month's standing the price will be reduced to 20 centimes (about 2d.). Thus says the *Bulletin International*, of Paris, to converse with Lyons will cost 1f. 80, subscribers 1f. 20; with Marseilles 2f. 70, subscribers 1f. 80; with Lille 90 centimes, subscribers 60 centimes; with Rouen 60 centimes, subscribers 40 centimes. The starting of this innovation rests with the

Minister of Posts and Telegraphs, who will require to be assured that the lines will be sufficiently employed before doing so.

New Cables to Brazil.—As will be seen from a report elsewhere, the Brazilian Government have at last, after protracted negotiations, authorised the Western and Brazilian Telegraph Company to lay alternative cables. The directors may be congratulated on the result of their efforts, which will reduce the risk of interruption to the traffic between this country and Brazil to a minimum. It would have been hardly fair on the part of the Brazilian Government to encourage rival competition. The company will proceed with the laying of the new cables as soon as possible. A report of the 20th ordinary general meeting is published in this issue.

Dublin Lighting.—A long letter from Mr. Sheriff Perry has appeared in the *Dublin Press* criticising the actions of the Electric Lighting Committee in that town, and generally inveighing against the authorities spending the public money in erecting a central station. Mr. Perry seems to be in favour of giving the lighting to contractors—that is, if he can be said to be in favour of electric lighting at all, which to him apparently still appears to be in the experimental stage! Mr. Perry seems to doubt whether the Electric Lighting Committee know anything at all about the matter they are dealing with. We fancy that the ignorance imputed to these gentlemen may be found existing in an active state outside the body of which they are members.

Electric Storage Car in Paris.—The Société pour la Travail Electrique des Metaux is running a storage car with Laurent-Cély cells, between the Palais de l'Industrie and the Place de la Concorde, on a narrow-gauge Decauville line. The car carries two Hillairet motors of 6 h.p. (French) each, the pulleys of which are geared to the axles of the car. The speed is reduced in the ratio of 1 to 10. There are 64 cells of 11 plates (20 cm., 7·8in. surface), which are arranged in eight boxes each, divided into eight compartments. The total weight of the car is 4,500 kilos (1 kilo = 2·2lb.). On starting, the discharge is 90, and when running normally, 45 amperes. This corresponds, says the *Bulletin International*, to 2·2 amperes per kilogram of plate. The weight of plates in the battery is 1,267 kilos, of a cell 19·8 kilos, and the gross weight of the battery 1,536.

Leeds Tramways.—An interesting discussion on a report by Mr. Hewson, borough engineer of Leeds, respecting the proposal of the Thomson-Houston Company to put their electric cars on the Roundhay Park route, took place at the Town Council meeting on Monday last. Apparently the only serious difference of opinion between members of the Council centres round the proposal of the company that after two years' running the Council shall purchase the plant, subject to a depreciation of 2½ per cent. It is thought that this figure should be raised to 7½ per cent. The result of the discussion was that a resolution was passed approving of the proposed arrangement with the company for the working of the tramway from Sheepscar to Roundhay Park, subject to further enquiry and approval by the Highways Committee. A detailed report will be found in another column.

Theoretically Perfect.—At the meeting of the Imperial Continental Gas Association the other day, a shareholder offered his fellows the following extraordinary crumb of comfort for digestion. He said that "the theoretical perfection of the electric light was more closely approached than was the theoretical perfection of gas, notwithstanding the many years that they had been making and using the latter." Taken as a compliment, this seems rather backhanded so far as our friends the gas managers are concerned. According to this statement, they are being left behind—in fact, are left behind, although they began the race first. The crumb of comfort was hard of digestion, we fancy, so far as the supporters of gas were concerned, because the Imperial Association is in a position to know something about the matter, having vended both gas and electricity for lighting purposes.

Electric Lighting in Monaco.—The concession for lighting Monaco has been granted to the firm of Lombard Gerin, Lyons, which has amalgamated with the Société Morégasque d'Electricité, which was formed by the Sociétés des Bains de Mer and Cercle des Etrangers. The concession is for 50 years, when the material in the public highways will become the property of the town, who will also be empowered to purchase the station at a price to be fixed by valuation. After 25 years the Government can insist on the method of distribution being reorganised and brought up to the standard of progress then existing. Authority is given to use the Zipernowski system with a maximum pressure in the primary circuit of 3,000 volts, and in the secondary of 120 volts. Earth returns are prohibited. The Government will give the site for the station, which is to have a capacity of 50,000 incandescents, and the ground required for conduits.

Bombay.—The Municipal Commissioner is inviting tenders for lighting certain streets of Bombay by electricity as an experiment. Tenders are to be sent in by 1 p.m. on the 16th February. Forms of tender and schedule of conditions, with a sketch of the portion of the city, showing the streets to be lighted, may be obtained from Messrs. E. W. and R. Oliver, 1, Corbet-court, Gracechurch-street, E.C., on payment of £1. Tenders must be accompanied by a deposit of Rs.1,000 in cash (not to bear interest), or in public securities for that amount, to be paid to the Chief Accountant of the Municipality of Bombay, which will be forfeited to the Corporation in case of refusal to sign the contract embodying the conditions mentioned in the schedule above referred to. A further payment to make the total deposit equivalent to 5 per cent. on the contract amount will have to be made by the tenderer whose tender may be accepted before signing the contract. The specification and conditions are given in our present issue.

Colliery Lighting.—Mr. André, writing in the *Colliery Guardian*, says: "Further experiments recently made at St. Etienne have clearly demonstrated that firedamp in its most sensitive state—that is, mixed with air in the proportion which gives the highest degree of inflammability—cannot be ignited by a spark from the pick. The sparks in this instance were struck from a hard iron ore—carbonate of iron. The recent explosions at St. Etienne have again directed attention to electricity as the only safe means of lighting fiery workings. The 'Stella' electric safety lamp, tried some time ago at the Anzin collieries, and since improved in construction, is much talked about. It is to be hoped that this problem of a practicable electric safety-lamp will be soon solved. The matter is worthy the attention of inventors, but for those who are not practically acquainted with the conditions of mining it is sheer waste of time to meddle with it."

Edinburgh Exhibition.—The climax to the series of regrettable incidents which have marred the end of this exhibition occurred on Saturday last, when, at the instance of the liquidator, Mr. Lee Bapty, general manager, was arrested at the Waverley Station, Edinburgh. The arrest was made under a warrant to prevent Mr. Bapty leaving the country until he had paid or found security for his contribution of £500 to the guarantee fund of the exhibition. At the Sheriff's Court, Mr. A. Mackenzie Ross, refreshment contractor to the exhibition, became security, and Mr. Bapty was liberated. He complained that no call had yet been made on the guarantors, and said he did not know why he should be singled out. He was on his way to Jamaica to manage the exhibition which is shortly to be opened there. Mr. Bapty was somewhat indignant at the course taken by the sheriff's officers, who, he said, might just as well have arrested him at his house in the exhibition grounds.

Lewes.—With reference to the discussion which has been going on at Lewes as to the lighting of the town by electricity, it is instructive to read a letter to a local paper from an old inhabitant of the town now living at Kansas, U.S.. He says that no one out there ever questions the superiority of electricity. "There are hundreds of miles of high-pressure wires for arc lights, to say nothing of the low-pressure ones for incandescent lights. All the principal thoroughfares, and public buildings and stores, are lighted with arc lamps, while the churches, residences, and smaller stores, and those requiring a soft light, use the incandescent. Notwithstanding this multitude of wires—which, with the telegraph and telephone wires, form a complete network over every street—during the two years I have been here not a single accident or fire has occurred, and I feel assured that with the safeguards with which we English surround everything no casualties of this nature need be feared."

The Royal Society.—The following is the list of names recommended by the President and Council of the Royal Society for election into the council for the year 1891 at the forthcoming anniversary meeting on December 1: President, Sir William Thomson, D.C.L., LL.D.; treasurer, John Evans, D.C.L., LL.D.; secretaries, Prof. Michael Foster, M.A., M.D., and Lord Rayleigh, M.A., D.C.L.; foreign secretary, Archibald Geikie, LL.D.; other members of the council, Prof. William Edward Ayrton, William Edward Mahoney Christie, M.A., Prof. W. Boyd Dawkins, M.A., James Whitbread Lee Glaisher, D.Sc., Hugo Müller, Ph.D., Prof. Alfred Newton, M.A., Sir William Roberts, M.D., William Chandler Roberts-Auston, F.C.S, Prof. Edward Albert Schäfer, M.R.C.S., Sir George Gabriel Stokes, M.A., Lieutenant-General Richard Strachey, R.E., Prof. Joseph John Thomson, M.A., Prof. Thomas Edward Thorpe, B.Sc., Sir William Turner, M.D., Prof. Sydney Howard Vynes, M.A., and General James Thomas Walker, C.B.

Electric Drills for Shipbuilding.—Electric drills are used with great success at Earle's Engineering and Shipbuilding Works, Hull. They are employed in drilling holes 2⅝in. diameter through the 2½in. steel protective decks of H.M.SS. "Endymion" and "St. George." One of these holes can be drilled by an electric drill in about 20 minutes, while at the Government dockyard, Devonport, it takes two men half a day to drill similar holes in a similar ship. The drill has been designed by Mr. W. H. Willatt, electrical engineer to the company. It stands on three legs, which are powerful compound electromagnets, capable of lifting 1,000lb. of iron each. To render the drill portable, eccentric wheel castors are attached to each leg. For drilling a hole the machine is brought over the place, the castors are turned up, and the magnets come in contact with the steel deck; the current is then switched on, and the magnets grip the deck. A motor on the machine operates the drill. Current is supplied from the circuit used to light the interior of the ship while the men are at work. Electric drills have been used in the U.S. Government yard at Brooklyn with good results.

Institution of Electrical Engineers.—Tickets have been issued by the President of the Institution of Electrical Engineers and Mrs. John Hopkinson for the *conversazione* in the galleries of the Royal Institute of Painters in Water Colours, 191, Piccadilly, on Wednesday evening, 19th inst., from 9 to 12 o'clock. We understand that in anticipation of the large numbers who are expected to respond to the invitation, the Princes Hall has been engaged in addition to the galleries of the Royal Institute of Painters in Water Colours. The second annual dinner is to be held at the Criterion Restaurant, Piccadilly, on Thursday, the 20th inst. The price of the tickets will be 10s. 6d., and forms have been issued by the secretary to be filled up by those intending to be present. Among those who have accepted the invitation of the President and Council are the Postmaster-General, the Attorney-General, the Presidents of the Royal Society, the Chemical Society, and the Institution of Mechanical Engineers, and the Vice-Presidents of the Institution of Civil Engineers, Sir Arthur Blackwood, the Astronomer-Royal, and Dr. Coleman Sellers, one of the members of the International Niagara Commission.

Brighton.—The memorial-stone of the generating station which the Corporation are building in North-road for the purpose of lighting Brighton by electricity, was publicly laid last week by the Mayor (Alderman Manwaring), who was presented for that purpose with a silver-mounted mallet and trowel. In the course of his remarks his Worship said he was not prepared to state that the scheme was going to be a financial success at first, but the town would eventually find that it had taken a wise course in adopting it. The station is being built by Mr. J. T. Chappell in accordance with plans and specification prepared by Mr. James N. Shoolbred, C.E. The works were commenced on the 1st October, and it is expected they will be completed by the end of January. The contracts entered into by the Town Council in connection with this station are as follows: Mr. J. T. Chappell, generating station, £3,989; Messrs. Yates and Thorn, three Lancashire boilers, £2,294; Sharp and Kent, steam dynamos, pumps, etc., £7,027; ditto, electrical instruments, £1,140; The Electrical Construction Corporation, two sets storage batteries, £2,700; Callender's Bitumen Telegraph and Waterproof Company, cables, leads, and wires, £9,300; ditto, street and other boxes, instruments, etc., £437. It is not proposed to use the light for street purposes or public lighting for the present, but to supply private consumers only.

Aluminium Production.—Among the works visited by the members of the Iron and Steel Institute during their American tour were those of the Pittsburgh Reduction Company, of which the *Iron and Coal Trades Review's* correspondent says: The object here is to make pure aluminium by means of electrolysis. The plant of the company consists of three Westinghouse engines, of the

united power of 525 horses, with boilers to suit; also two 100-ampere 25-volt Westinghouse dynamos, and two dynamos of 2,500 amperes and 50 volts each. The company manufacture under the patents of Mr. C. M. Hall for effecting the continuous electrolytic reduction of the oxide of aluminium. This is done in wrought-iron tanks lined with carbon. A number of carbon anodes are inserted vertically into these tanks, and connected with the dynamos, the baths themselves acting as cathodes. The contents of the baths consist of aluminium oxide, together with certain fluxing material in a molten state, the electric current maintaining the heat and effecting the reduction. Fresh oxide is added at intervals to the baths, and the metallic aluminium, being of greater specific gravity than the slag, sinks to the bottom as fast as it is reduced, and is ladled out from time to time. It is then re-melted in crucibles for purposes of purification, and cast into ingots. The present capacity of the works is 375lb. per day.

Brussels Conservatoire.—We alluded to the lighting of part of this building by means of a primary battery not long ago. A Belgian paper now says that the name of the inventors is MM. Buffet and Duvivier, and that the bye-products are so valuable as to pay for the light. The battery charges accumulators which feed the lights. Our contemporary contents itself with descanting on the youth of the inventors (not always a recommendation), and the wonderful things the battery will accomplish if that which is promised of it is realised. From another source we gather that Messrs. Bède and Lucien have reported on the battery, and that it resembles a Bunsen cell in some respects. It consists of a glass jar, a carbon plate, and a porous jar and zinc plate. The zinc is immersed in pure water, contained in the porous jar, and the carbon in a solution of nitrate of soda, with a little sulphuric acid added. This mixture is decomposed when the plates are connected. The nitric acid is set at liberty little by little, and burns up the hydrogen set free at the zinc, whilst the oxygen liberated combines with the metal to form oxide of zinc On open circuit the battery is almost inactive, and only gives off a small amount of nitrous gas. The bye products, oxide of zinc and salts of soda and zinc, are in part recovered; the remainder can be used as a fertiliser by adding phosphate of lime. The report states that the battery will work for 120 consecutive hours with the same charge, and that the actual consumption of zinc is found to be fairly in accordance with the theoretical value. It is stated that the inventor will show his battery at work in Paris. The details are too meagre to afford any information of value, and they have a striking family resemblance to former attempts in the bye-product direction.

Brussels.—The Tudor Company have erected a station at the Passage du Nord, Brussels. There are two condensing engines (Rider-Bollinck make) of 50h.p. each, and two Mattot boilers, one having 55 metres, the other 85 metres of heating surface specially constructed for fitting up in a narrow space. Two Thomson-Houston dynamos of 16,800 watts each (140 volts at 120 amperes) and one Siemens dynamo of 40,000 watts (140 volts and 290 amperes) form the generating machinery. The shafting is so arranged that either engine can drive either of the dynamos. The foundations are specially constructed to avoid vibration. The accumulator-room is above the engine-room; there are 264 cells grouped in four parallel series of 66. The plates are 550 by 420, and each cell weighs 230 kilog. The available capacity of the battery is 756 amperes, the charging current is 95 amperes, and the discharge 126 amperes. When in full work the station will feed 2,000 16-c.p. lamps. Metallic returns are used. The overhead circuit is run with phosphor bronze wires ($^{36}/_{10}$). The wires are insulated by order of the authorities. The *personnel* of the station includes an electrical engineer, a mechanic, and a stoker. An optical and acoustic signal is provided to warn the electrical engineer when the pressure in the circuit varies by one volt. The Café Métropole is the chief consumer up to the present, with 600 lamps. The firm of Cartaut takes 400 lamps. The station has already a guaranteed minimum consumption for the next 10 years, which means 35,000f. in receipts per annum. The installation was carried out by M. Vandewiele, engineer, under the direction of M. H. Dratz, formerly managing director of the Tudor Company, and now manager of the Lamp Manufacturing Company at Schaerbeck.

Resistance of Metals.—In a note to the Academy of Sciences, Mr. H. Le Chatelier says: "When silver is heated in oxygen its resistance curve remains perfectly rectilinear, its mechanical properties are not modified, and its melting point is found to be 945deg., which is practically identical with the 954deg. given by M. Violle. When heated in hydrogen, however, all its properties are modified when 650deg. is passed. Its electrical resistances increases more rapidly than in oxygen; the metal, after being cooled, is very fragile, and wires of ·25 mm. diameter cannot be bent without breaking; finally, the melting point is lowered to 915deg. These facts point to the absorption of hydrogen by silver at red heat. I am certain that the quantity of hydrogen absorbed is not sufficient to form a definite combination, and that the metal does not after cooling retain any appreciable quantity. A large number of metals, like iron, present rapid molecular transformations, which are produced at well-defined temperatures. Electrical resistances show at these temperatures sharp variations in their law of increase. But the absolute value undergoes no change in passing a point of transformation when it occurs at the melting points. Curves are given showing these phenomena, the clearest of which was observed with an alloy of Cu = 70, Ni = 18, and Fe = 11. The temperatures of molecular transformations found were for Zn 360deg., brass (38 per cent. of Zn) 720deg., alloy of Cu, Fe, Ni, 690deg. With brass the transformation is accompanied by a considerable absorption of latent heat. Some alloys show progressive molecular transformations which resemble those observed in the chemical equilibrium of salt solutions, such as chromic salts, chloride of copper, etc. Such is the case with slightly silicious bronze aluminium, the transformation of which occurs between 550deg. and 650deg. The metal should be tempered at a temperature above the latter figure. But this peculiarity is especially shown to a high degree in German silver, and the alloys of copper and nickel. When the alloys are heated their resistance decreases considerably—from 300deg. to 500deg. To observe this phenomenon, it is absolutely necessary to use a metal that has been annealed, and cooled again very slowly. The temper of the German silver can only be more or less completely avoided, by allowing it some hours to clear the interval of temperature from 500deg. to 300deg. Iron, nickel, and their alloys show, at temperatures above that of transformation, a law for the variation of their electrical resistance which is analogous to that of platinum and its alloys. At lower temperatures, on the contrary, the law of variation is infinitely more rapid."

GENERAL INSTRUCTIONS FOR OVERHEAD LINE CONSTRUCTION FOR ELECTRIC RAILWAYS.

The large amount of overhead railway work now in course of construction, and the large number of roads which will undoubtedly be constructed in the future, makes it desirable to have some clearly-defined rules for the construction of overhead work, as well as that relating to the ground conductor. Our readers will therefore be interested in the admirable general instructions relating to this part of railway work, which have been issued by the Westing house Electric and Manufacturing Company, and which, if carried out faithfully, cannot fail to result in a substantial and lasting conductor system, with the least possible annoyance to the public.

Franchises, Permits, Etc.—The owners of the railway must secure all necessary franchises and permits from public authorities, or private individuals, for properly carrying on the work of construction, including permission to set poles in the most advantageous positions, and to run guys where necessary. They shall also do all necessary removal or trimming of trees, and shall be responsible for all necessary removal of existing wires or poles or other impediments.

Contractors.—The contractors shall comply strictly with the local laws governing their work, and are responsible for all unlawful damage done by their employés in the progress of their work. They are required to do all the carting and storing of material, to furnish all horses, waggons, men, and material for carrying on work.

Completion of Work.—Each branch of the work must be pushed rapidly to completion as taken up, all resodding, paving, etc., promptly done, and all débris and material removed. All breakdowns, or deteriorations of the work, which shall occur before the final completion and acceptance of the whole, shall be repaired and made good by the contractors at their own expense.

Inspection and Acceptance of Work.—The electric company may appoint an inspector, who shall have authority to decide and direct how every branch of the work shall be done and what material shall be used. He may at any time order such changes and removals as he may see fit. If the inspector orders any work done or materials used which are not properly included in or covered by the contract, he shall give a written order to the contractors, specifying, as nearly as possible, the amount of labour and material involved. The inspector will give a written acceptance to the contractors when he considers their work properly completed.

Track and Ground Connections.

On all roads where the size and material of the continuous ground wire are not particularly specified, No. 0 B. and S. galvanised iron wire shall be used. All joints in it shall be soldered. It shall be stretched taut, and secured to cross ties or stringers with galvanised staples. It must be so deep in the ground that it cannot be reached by wheels, etc. It must be run close to one rail and connected to each rail bond it passes by a wrapped soldered joint. Every 150ft. a branch of No. 0 B. and S. wire shall be soldered to the continuous ground wire and to a rail bond on the other side of the track. Where there is a double track, there must be a cross wire every 150ft., which is soldered to bonds on ground wire on all four lines of rail, and is the only cross connection required. It must be of No. 0 B. and S. (See Fig. 1.)

Between the ends of all consecutive rails, of whatever form, a rail bond, the electric company's standard pattern, shall be used. This bond is shown in Fig. 1. The holes in brass or copper block must be bored to fit rivet and wire, not punched. The end of wire must be put through block, and upset so that it cannot pull out, and the whole bond must be covered with half and half solder. The rivet must be Norway iron, $\frac{5}{16}$in. in diameter, and of just sufficient length to pass through flange or web of rail and be riveted.

The best place for rivet holes in different kinds of rails depends to a great extent on paving and other conditions. The rivet must always pass through the rail, and be upset into a counter-sinking at the end of hole. No part of the bond must be exposed or placed in such a manner that it can be touched by wheels, or that the movements of the rail will tend to break the wire. The admissible positions for rail bond rivets in girder, T, and tram rails are shown, Fig. 2. No rail bond may be less than 10in. in length, and the bonds must be slack when in place, but as short as the conditions will permit. Where short pieces or castings—such as switches, frogs, or curve castings—occur in track, the pieces must be connected up in the same manner as consecutive rails, and each bond soldered to the continuous ground wire.

In steam railway crossings, each piece of rail must be connected to the continuous ground wire. Where a drawbridge is crossed the rails on either side should be connected by a No. 0 B. and S. copper wire, weighted to the bottom of water, with such connection as is necessary for rails on draw.

Cables or wire leading from rails to dynamos must be soldered to continuous ground wires and bonds on all lines of rails, and must be connected to the positive terminal of dynamos. When ground feeders are run, they must be insulated in the same way as line feeders, but must, if possible, not be run on the same line of poles, and in no case must they be run on the same insulated pole tops.

Poles.

Wooden Poles.—Must be 30ft. long, and for use on straight lines must not be less than 7in. or more than 8in. in diameter at top when finished, and they must not be less than 10in. in diameter 5ft. from the butt. They must be of sound chestnut, cedar, or Georgia pine, may be sawed or natural round, but in both cases must be dressed smooth and coned at top, cones having two coats of paint.

Poles for Corners.—At curves and for the ends of line, or which in any way bear part of the pull of the trolley or feed wires, must be not less than 8in. in diameter at top, and not less than 12in. at a point 5ft. from the butt. All poles must be straight and uniform, and free from shakes, checks, or large knots.

Iron or Steel Poles.—Of whatever form shall be of a strength and stiffness at least equal to the wooden poles specified. A pole made of three sections of extra heavy pipe, top section 3in. pipe 5ft. long; middle section 4in. pipe 6ft. long, and bottom 5in. pipe 16ft. long (these lengths do not include the lap in joints), is sufficient for light work. All joints must be made perfectly rigid and as strong as the adjoining pipe, with proper provisions against telescoping.

All iron poles must have a thoroughly insulated iron top to which wires are secured. This should be mounted in a hardwood plug in pole top boiled in paraffin. The top must protect the plug entirely from water; it must have a deep petticoat extending at least 1in. below pole top, and standing at least 1in. clear of it on all sides. This top must be fitted with fixtures for securing span wires and insulators for feed wires, etc.

For Curves.—Angles of feed wire, and ends of line, etc., extra strong poles must be used. There is nothing in the work of building a line so essential to its durability and good working as is the perfect rigidity of corner poles. The top section of curve poles should in no case be less than 5in. extra heavy pipe, and, of course, special insulated tops must be provided for them. Corner poles must be fitted with strong eye-bolts below the wooden plug for fastening guys.

Pole Setting.—All poles on straight line work shall be set 6ft. in the ground. Large stones shall be tamped hard against butt of pole on side away from rails. Where practicable, pole should bear at surface of ground against kerbstone, or have the space between it and kerbstone filled by another stone or stones. Where there is no kerbstone, a timber, not less than 4in by 8in. and 3ft. long, shall be laid against the rail side of pole, 6in. below the surface of the ground. A large stone, at least 2ft. long and 1ft. wide, should be used in place of timber when practicable. All poles shall be tamped solidly. (Fig. 3.)

In setting iron poles, good cement concrete must be used. The quality of the concrete should in all cases be good at the top and bottom of holes, and large stone may be used at these points to advantage. The hole in which an

iron pole is set should be at least 20in. in diameter, and filled with concrete, which should be given ample time to set before any strain is put on it. Poles of wood or iron for straight line work should have about 3 per cent. of rake away from street, Fig. 3. Wherever possible, the line of the tops of poles should be at a uniform height from rails, and the ground around poles should be graded to give the pole the proper depth of setting.

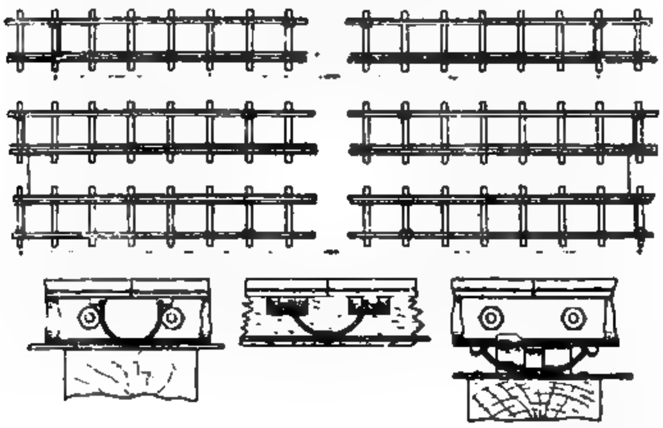


FIG. 1.—Method of Connecting Ground Wire, Single and Double Track.

Poles which support part of the strain of curves or bends of trolley or feed wires must in all cases where it is possible be thoroughly head guyed. When this can be properly done no extra precautions need be taken in setting, and poles should be set nearly vertical. The same applies to poles which support ends of lines.

Guy stubs must be anchored 5ft. in ground, and their tops must be 6ft. above ground; the stubs must be at least 8in. in diameter, and must rake well towards pole top or point directly towards it. Guys must make no metallic contact with insulated pole tops, or with any other wires which lead from the pole. Guys must be made of twisted

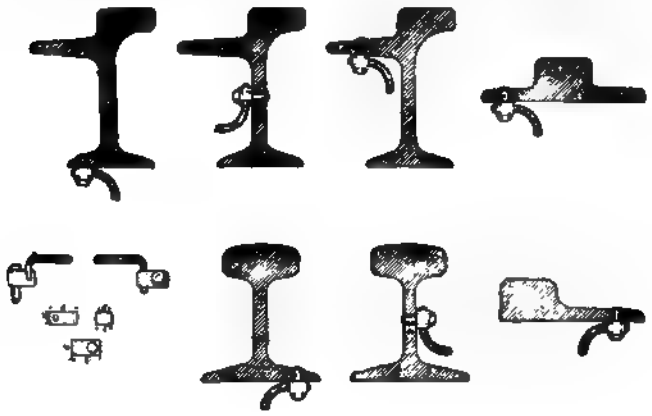


FIG. 2.—Method of Connecting Ground Wire to Rail.

(doubled) No. 6 galvanised wire, or something equally strong or durable, Fig. 4. When guys cannot be used on the poles above-mentioned, they must be set 7ft. deep in a hole 30in. in diameter, and built in solid with stone and concrete. Poles shall not be more than 125ft. apart, except where a greater distance is unavoidable.

In all cases where the character of the soil or the nature of the strains make the ordinary method of setting poles inadequate, precautions must be taken to make poles sufficiently firm, and whenever poles yield under the strain put upon them, the electric company's inspector may have them reset at the contractor's expense. This may also be done when poles are displaced by undue strains imposed by contractors in building line, etc.

When the poles are not set by contractors who put up the wires, the latter must assume responsibility for the rigidity of curve and terminal poles, and their work can in no case be made acceptable unless these poles are thoroughly strong and firm or properly guyed.

FIXTURES.

All insulator pins and pin brackets shall be of the best oak or locust. Pin brackets shall be secured to pole with one 5in. and one 7in. lag screw.

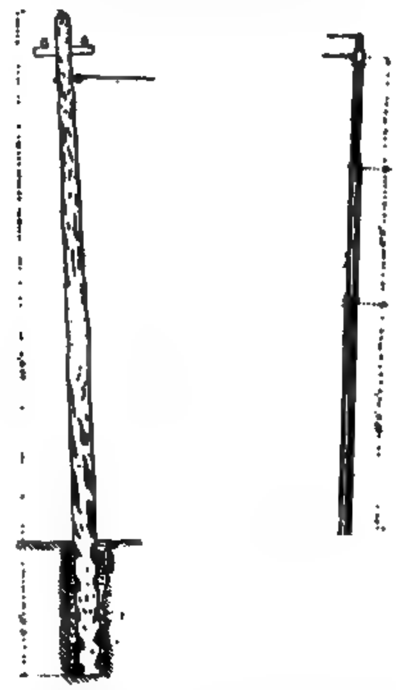


FIG. 3.—Method of Planting Wood Pole and Iron Pole.

Cross Arms.—Shall be of the best pine, 3¾in. by 4½in., painted with two coats Indian red. They must be secured in perfectly fitted gains with two 7in. lag screws. Insulators must be extra heavy, such as are made for the largest

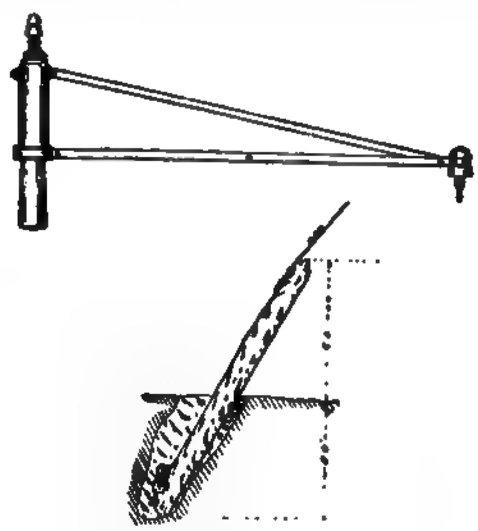


FIG. 4.—Guy Stub and Outrigger.

sizes of wire. Where sharp turns are made with heavy wires, two or four cross arms must be used, and, where necessary, iron pins and large paraffined wooden insulators may be used.

(To be continued.)

LONDON CHAMBER OF COMMERCE.

It is well known that the Electrical Section is discussing a scheme for obtaining information, and the following letter has been circulated. The tables on next page give an idea of the kind of information wanted:

To the Secretary or General Manager ——— Lighting Company.

Dear Sir,—We shall be glad if you will bring before your board of directors, or board of management (as the case may be), the following matter.

A great many English electrical engineers believe that the

TABLE I.—EFFICIENCY AT VARYING LOAD FACTORS.

—			A.	B.	C.	D.
Evaporative Duty of Boilers in lbs. of water per lb. of fuel.........						
Duty of Engines in lbs. of steam per Indicated H.P. per hour.........						
Steam Engine Efficiency	or	Brake H.P. / Indicated H.P.				
Dynamo Efficiency	or	Electrical H.P. at Terminals. / Brake H.P. of Engine.				
Total Generating Efficiency	or	Electrical H.P. of Dynamo. / Indicated H.P. of Engines.				
Distribution Efficiency	or	Electrical H.P. delivered to users. / Electrical H.P. at Terminals.				
Total Efficiency	or	Electrical H.P. delivered to users. / Indicated H.P. of Engines.				
Load Factor..			100			

A. The figures for this column are those that have been obtained by actual test at trial runs at full power a sufficient number of hours to show that same results could be obtained from plant if run continuously the year round at full power. The 25 per cent. reserve plant being considered sufficient to allow every part of plant to be repaired and kept in thorough order. As such a condition has never yet been obtained in practice, of course all figures must be calculated.

B. Figures from 12 months' continuous working taken from the monthly or annual account of coal, water, and other materials used.

C. These figures to be same as B, but for one month of heaviest load.

D. Same, for one month of lightest load.

By Load Factor is meant the relation which the actual output delivered to users bears to the actual output if plant were worked continuously throughout the year at its highest observed power, the factor for column A being 100.

For Example.—If the plant, after allowing 25 per cent. for extra or reserve machinery, is capable of delivering electrical energy to the consumer at the rate of 133 electrical h.p.—that is, 100 units per hour, or 8,760 hours × 100 = 876,000 units per annum. Then if the actual demand reached this figure the load factor for columns B and A would be 100. But if the annual demand were 96,000 units, of which 12,000 were for December and 4,000 for July, the load factors for B, C, D would be 11, 16·4, and 5·5 respectively.

TABLE II.—COSTS.

—	B.			C.			D.		
	Per Ind. H.P.	Per Unit Genert'd	Per Unit Sold.	Per Ind. H.P.	Per Unit Genert'd	Per Unit Sold.	Per Ind. H.P.	Per Unit Genert'd	Per Unit Sold.
Fuel									
Water									
Petty stores...									
Repairs and renewals of generating plant (inside)......									
Engine-room wages									
Superintendence.....									
Total cost of generating the energy.....									
Repairs and renewals of distributing plant...									
Wages outside generating station									
Superintendence ditto									
Total cost of distribution............									
Total cost of producing and distributing the energy									

The columns B, C, D correspond to similar columns in Table I., that is to say, the costs there recorded are to be annual, best and worst month respectively, in all cases to be from actual accounts, without deductions or allowances. In order to bring repairs and renewal of plant to a common basis of calculation, it is requested that the annual sums to be divided into the units, be taken at the following percentages on original cost of plant:

2½ per cent. on buildings, brickwork, and masonry.
5 per cent. on boilers, pipes, engines, dynamos, switchboards, and all cables, or other conductors covered with continuous insulation.
1 per cent. on bare conductors insulated by means of glass, porcelain, or other such like imperishable materials.
15 per cent. on accumulators and transformers.

Superintendence.—The wages of same to be divided between costs of generating and distributing, according to time occupied by each.

progress of the industry would be more rapid if there were, among the electrical engineers of all countries, a fuller interchange of ideas, and a freer publication of the data which are obtained in the practical working out of many of the great electrical problems which every day present themselves to us.

It has been proposed at a meeting of the Electrical Section of the London Chamber of Commerce, that steps should be taken to ascertain whether it is not possible to obtain mutual benefit from publication and circulation of a quarterly report compiled from data furnished not only from the various electrical manufacturers and electrical supply companies in the United Kingdom, but from those of the whole world, so far as it is possible to obtain them. In order to carry this out, it is thought that a start should be made in London by the Electrical Section of the London Chamber of Commerce, who would seek to add to their members as many foreign corresponding members as possible.

With this end in view, I beg to ask you whether your company would become members of such an international society. The terms of membership would be:

(1) A small subscription to meet the cost of printing, postage, etc.

(2) The members would be required to communicate to the head offices in London, from time to time, a correspondence letter giving in general terms the progress of the industry.

(3) The members would be required to fill in, as far as they could do so without injury to themselves, on forms which should be from time to time furnished to them, the cost of production of electrical energy for lighting and power in a tabulated form under the various headings of material, labour, superintendence, wear and tear, renewals, and the other charges which go to make up the cost of production. In return for this they would each receive a copy of the quarterly report, in which would be added the whole of these correspondence letters and the whole of the tabulated data.

We may add that the great steel industry of England and America and on the Continent was very greatly benefited by a similar course in the early days of the Iron and Steel Institute, who took great pains to tabulate the results of blast furnaces, Bessemer converters, and such kinds of apparatus, and there is no doubt that enormous benefits accrued to that industry from the study and comparison of the data obtained and circulated by means of the journal of the Iron and Steel Institute.

LEEDS TRAMWAYS.

PROPOSED ELECTRIC CARS FOR THE ROUNDHAY PARK ROUTE.

At the meeting of the Leeds Town Council on Monday last Alderman FIRTH moved that the Council approve of the proposed arrangement with the Thomson-Houston International

Electric Company for the working by the company, with their system of electricity, of the tramway from Sheepscar to Roundhay Park, subject to the terms and conditions now submitted to the Council. He said it would be familiar in the minds of most members of the Corporation that the Highways Committee had come to some understanding with the present tramways company, and that the moment that this matter was about to be introduced to the Council a letter was read from a firm of solicitors in the town calling the attention of the Council to the fact that if the whole system of tramways were thrown open to public competition a larger price could be obtained. The matter was sent back to the Highways Committee, and they had gone carefully into the question. An application came before them from the Thomson-Houston Electric Company for the privilege of trying their system upon the Roundhay-road length of line. The proposition arose from the company themselves, and it was not sought, so far as the Highways Committee were concerned. It was necessary that the Council should be clear that the Highways Committee, in bringing this offer before the Council, did not mean it to be understood for one moment that that committee had considered the general question of working tramways by electricity, nor whether this particular company's system was to be preferred to all others. By the action of the Council themselves the Highways Committee had the Roundhay-road tramway on its hands until August, 1892. The offer now before the Council was brought by the committee as one which, if adopted, would fill up a gap in the public requirements for the next two years, and would be a cheap though valuable experience for the Council and the public. The company were, at their own cost, to equip the line with cars and with all the rolling-stock; they were to find the means of generating their electricity at their own cost and at stations to be provided by themselves. So far as the Council was concerned they were expected to find the company a shed wherein to store their cars, and a small workshop, but the position where that shed should be placed was to be determined by the Council. They would find that when the agreement expired, that was when the lease of the present tramway company expired, the Thomson-Houston Company did not hold the Corporation responsible to take over their plant or their generating system, unless electricity as a motive power for the entire system of tramways in Leeds had been adopted. If no system of electrical motive power was adopted, then they had to take away their plant at their own cost. In addition to that they had to leave the streets as they found them. He was not an electrician, and therefore he thought it was necessary that Mr. Hewson, their engineer, should prepare a report in order to guide the Corporation to a proper solution of the question. Mr. Hewson's report with reference to the Thomson-Houston system contained the following: "This system has under the bottom of the car an electric motor or engine, which, by passing a current of electricity through it, is made to propel the car. This current is generated at a works or station, which may be placed anywhere within a mile or two from the tramway. The current is led outward from the station by a wire carried on poles, and completes its circuit by means of the rails of the tramway. The connection between the car and the outward or pole wire is made by a travelling wire suitably fastened to the car, and connected with the outward or pole wire by a pulley runner. The poles carrying the wire will be placed against the kerbstones at distances of about 40 yards apart. From each pole a wire will extend across the roadway. To this cross wire will be attached the outgoing wire conveying the current from the central station the whole length of the tramway, to which wire the pulley runner before described as conveying the electricity to the car will be fixed. The tension or pressure of the electricity used in this will be 500 volts. Most of the distributing wires laid or now being laid in London are to work at a pressure of 2,400 volts, and are under Government inspection. All that will be required for the ingoing or return current will be to connect the tram rails across the joints with a copper wire, and this will be done by simply taking out a paving stone at each joint, making the connection, and replacing the stone. Sparking or firing the rails never takes place, excepting when the rails are rusty, and the traffic, tram or otherwise, is too great in Roundhay-road for rusting to take place. The consent and approval of the Board of Trade, not only to use electricity for the tramway, but of every detail of the system and of the material to be used, will have to be obtained. The present tramway would not have to be altered to suit the adoption of the system or its abolition. No shocks or annoyance to passengers will occur, as when the machinery is in working order the electric current is not only insulated, but is cased off; and in case of breakage of the wire the current stops instantly. The cars will be made to carry 62 passengers. They will be of the most modern two-floor pattern. Having to carry the motor, they will be 1½ tons heavier than they would otherwise be. The motor and car will weigh together 5½ tons. The motor will be 16 h.p. The weight of a steam tram engine of the same horse-power is from 10 to 12 tons—say, 10 tons; therefore the weight of a steam tram engine and car will be 14 tons, as compared with 5½ tons, the weight of an electric car. This difference in weight is much in favour of the electric car, not only by reason of the reduction in the cost of hauling, but in the greatly decreased wear on the rails. The electric cars can easily run 20 miles an hour on an ordinary road, and eight miles per hour on a rising gradient of 1 in 13 as in Cookridge-street. In the case of an electric car having a second or train car attached, it would be able to mount Cookridge-street at certainly five miles per hour. Electric cars only occupy half the space that steam engines and cars do, and they run equally well both ways, and, carrying their own power, will not involve the shunting at the end of their journeys that steam does. Electric trams are possible in narrow, crowded thoroughfares where steam trams would be impracticable. A much greater extension of tramways on the electric system could be made in Hunslet than on the steam system. The electric car gives out neither steam nor smoke to annoy the public or injure its health, or to frighten horses." The company, Alderman Firth said, referred him to a gentleman who was well known—he meant Mr. Arthur Greenwood. That gentleman told him he had not seen the cars running in America himself, but some of his friends had, and they were perfectly satisfied with what they had seen. He had also spoken to Sir James Kitson, who had just returned from America, and he told him that the cars could mount any reasonable gradient, but when riding in those cars one felt a noise arising from the machinery working underneath, which was not felt in the ordinary steam car. Sir James went on to say that there was the question of the overhead line, and that was a very objectionable feature. There was no doubt that it was objectionable, and the committee did not disguise the fact. If they had a choice they would much prefer not to have the overhead wires; but if the experiment was to be tried in Leeds it must be tried somewhere, and if the worst came to the worst it was only a question of trying it for two years at the outside. Replying to a question asked by Mr. Teale, Alderman Firth said the building proposed to be erected would accommodate eight cars. It would be 100ft. long by 40ft. wide, and would cost £850.

Sir Edwin Gaunt seconded the resolution. He thought the experiment would be of immense value. If the company had not agreed to pay anything for the use of the line, and the expense which the Corporation would be put to had been greater, he should still have been in favour of the resolution.

Mr. Gordon moved that the question be referred back to the committee. He did not do so in any hostile spirit, for he thought they would act foolishly if they did not allow the company to make a trial. But there were one or two clauses in the agreement which, in his opinion, required altering. The proposal that if the Corporation decided to carry on the electric tramway at the termination of the two years' lease they should purchase the plant at cost price subject to a depreciation of 2½ per cent., was ridiculously inadequate. He should have considered a depreciation of 7½ per cent. a far more likely figure.

Mr. C. H. Wilson seconded the amendment. Although, he said, the town might gain much by the experiment, it would be at a great cost. Then he thought the proposed poles and wires would be ugly and dangerous.

Alderman Scarr observed that many of his objections to the electric tramway had been removed by the speech of Alderman Firth. He, however, agreed with Mr. Gordon that a depreciation of 2½ per cent. was too small. He hoped the suggestion thrown out respecting the projected line down Becket-street and York-street would be carried out. It would be a most valuable acquisition to the tramway system of the town.

Mr. Ambler urged the members of the Council to vote for the resolution, so that they might have the line in working order early in the new year.

Mr. Wormesley and Mr. Teale also approved of the scheme.

Alderman Firth suggested that, to meet the wishes of Mr. Gordon, the resolution should end "subject to further enquiry and approval by the Highways Committee." He said he would try to have the agreement altered in accordance with the suggestions which had been made.

Mr. Gordon thereupon withdrew his amendment, and the resolution was carried by 47 votes to six.

ON THE ELECTROSTATIC FORCE BETWEEN CONDUCTORS CONVEYING STEADY OR TRANSIENT CURRENTS.*

BY DR. OLIVER LODGE.

(*Concluded from page 415.*)

Action of Moving Charges and Pulses.

So far, I have not taken into account the sinuosity of distribution of Leyden jar discharges in space, nor the possibility of pulses passing the two portions of the circuit between which the force is being observed at different times or in different phases. It would seem as if a small assemblage of short-waved pulses sent round a long circuit might be prevented from exerting any

* Paper read before the British Association.

mechanical action on each other if the adjacent parts of the circuit in which their action was to be observed were purposely separated by an intervening length of wires of many wave-lengths unsymmetrically introduced into the circuit. But before committing myself I should like to make a few experiments. Nevertheless, I am tempted to go on a little further.

If, instead of considering pulses rushing along stationary wires, we consider charged wires moving along endways with the speed of light, Mr. Heaviside has attacked the general problem in the *Phil. Mag.* for April, 1889. He there shows that between two planes perpendicular to a wire thus moving and moving with it at a distance apart equal to the length of the wire, the electrostatic intensity is

$$E = \frac{2\lambda}{K r},$$

and the magnetic intensity is

$$H = \frac{2\lambda v}{r},$$

where λ, the linear density, may be distributed anyhow on the wire. Outside these two planes the force is zero.

If the two intensities were to act, one on a stationary charge of any number of electrostatic units, the other on a stationary magnetic pole of the same number of magnetic units, the two forces would be equal. If they act on a wire conveying a steady current, and charged up to a certain linear density, the forces will be equal when the statistical measure of density is equal to the magnetic measure of current—*i.e.*, when $C = v\gamma$; for then

$$E\lambda = H\mu C.$$

Lastly, if the two forces due to one bit of charged wire, moving in its own line with the speed of light, act on another similarly moving piece, the current equivalent to the second wire will be $v\lambda'$; and again there will be an equality between electrostatic and electrokinetic forces;

$$\frac{2\lambda}{K r} \cdot \lambda' = \frac{2\lambda v}{r} \cdot \mu \lambda' v.$$

Not by any different λ, or by any rearrangement of λ, can the balance be disturbed: only by a different v. If either wire moves with velocity less than that of light, the electrostatic force overpowers the other, but so long as the full velocity is maintained the density on either wire may have any value, positive or negative, without disturbing the balance; and this is natural enough, when, as here, λ and C vary together, for if λ be zero or negative anywhere, C is also zero and negative, and the balance persists.

Now, proceed to the case of alternating pulses travelling along parallel stationary wires. Their speed of travel is the speed of light, and though the distribution of both density and current is sinuous there is nothing in that disturbing to a balance. Moreover, so long as the waves are freely progressive, λ and C still accompany each other exactly, and nothing but a balance will be observed in a closed circuit, however the phases operating in the acting portions be altered, if the right proportion holds between the current and the potential, as already calculated.

But if by reflection at distant unjoined ends of an open circuit the pulses be turned from progressive into stationary waves, then localities can be found on the wires at which attraction or repulsion permanently occurs; for λ and C are no longer companions, the sinuous distribution of current lags a quarter period behind the sinuous distribution of charge. Hence at a given instant there will be places where the current force is a maximum and the static force zero; while at a quarter wave-length on either side the current force is zero and the static force a maximum. Halfway between these places only will the two forces be equal, but with alternate agreement and disagreement of sign. A readjustment of phase between the conductors will now make all the difference; a shift of a quarter wave-length changing from maximum to zero, and a shift of half a wave-length bringing about reversal of sign.

According to all this, therefore (if it be correct), it follows that the simple ideas on which Mr. Boys set to work are right after all, and that he will detect the forces in the way he expects.

Variation with Distance.

A few words as to the magnitude of the effect to be expected. Hertz has shown (see *Nature*, vol. xxxix., p. 404) that at a reasonable distance from a rectilinear oscillator, one or two wave-lengths being practically sufficient, the electric force (or electromotive intensity) is perpendicular to the radius vector from middle of oscillator, and is of magnitude

$$E = \frac{Q l q^2}{K \rho} \cdot \sin(q\rho - pt) \cdot \sin\theta; \quad . \quad . \quad . \quad . \quad (8)$$

where ρ and θ are the polar co-ordinates of the place, and $q = 2\pi/\lambda$.

Calling the length of the oscillator the axis, and the normal plane through its middle the equator, this means that the electric force is maximum at the equator, diminishes towards the poles, and varies along any radius with the inverse distance from the centre.

At smaller distances the law is not so simple, but at any distance in the equatorial plane the electric oscillation is parallel to the oscillator, and of amplitude

$$\frac{Q l}{K r^3} \sqrt{(q^4 r^4 - q^2 r^2 + 1)},$$

showing that close to the oscillator the electric force varies as the inverse cube of the distance, at intermediate distances more slowly, while at a very few wave-lengths (practically one is sufficient) the first term under the root overpowers the others, and the ordinary law of the inverse distance holds good.

To get an idea of the magnitude of this intensity at any considerable distance from the axis, write $Q = S\,V$, where V_0 is measured by the length of spark employed at the oscillator, and write for q^2 its value $\frac{\mu K}{L S}$; then the amplitude of the electric force is

$$E = \frac{S V l \cdot \mu K \cdot \sin\theta}{K \rho \cdot L S};$$

or, as $L = 2 l \mu \left(\log \frac{4l}{d} - 1\right) = 2\mu l c$, say,

$$E = \frac{V \sin^2\theta}{2 r c} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Take as a numerical example any convenient oscillator, say, to avoid unnecessary repetition of specification, the small oscillator drawn to scale on page 54 of the *Philosophical Magazine* for July, 1889, which emits waves one metre long. Let its constant $c = 4\frac{1}{2}$, and its spark be, as there quoted, eight millimetres, so that V_0 is about 26,000 volts. Then the initial electric intensity at a distance of a couple of wave-lengths in the equator is

$$E_0 = \frac{26{,}000 \text{ volts}}{18 \text{ metres}}$$
$$= 14{\cdot}4 \text{ volts per centimetre.}$$

Putting, therefore, at this distance of two metres a parallel wire half a wave-length long as receiver, it utilises 50 centimetres of the above E.M.F., and gives a maximum sparking potential of 720 volts, which corresponds to a spark-gap of about a tenth of a millimetre between flat surfaces. This is an upper estimate, because time for a quarter-period's dissipation should be allowed, the result being multiplied by a dissipation-factor *exp.* $\left(-\frac{\frac{1}{4}\lambda}{v S R}\right)$; where R is to be found as follows.

Energy of Radiation.

The mean energy of the radiation per unit volume is, as is well known (Maxwell, art. 793), $\frac{K E^2}{8\pi}$; which, in the present case, abbreviating the characteristic factor, $\left(\log \frac{4l}{d} - 1\right)$ or its equivalent to c, is

$$\frac{K}{8\pi} \cdot \frac{V^2 \sin^2\theta}{4 \rho^2 c^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

The energy sent per second through the sphere of radius ρ with velocity "v" is

$$\int_0^\pi 2\pi\rho\sin\theta \cdot \rho\, d\theta \cdot \frac{K V^2 \sin^2\theta}{32\pi\rho^2 c^2} \cdot v$$
$$= \frac{4}{3} \cdot \frac{K v V^2}{16 c^2}$$
$$= \frac{V^2}{12 \mu v c^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

And this is the rate at which the oscillator radiates energy during its activity. Comparing (11) with (10) we see that the equatorial radiation exceeds the mean radiation in the proportion of 3 : 2.

The difference of potential, V, is not constant, but decreases logarithmically according to the law

$$V = V_0 e^{-\frac{t}{SR}};$$

where R is a dissipation-coefficient of the dimension of resistance, and of value easily found, thus:

Total energy radiated for every spark of the oscillator is

$$\int_0^\infty \frac{V_0^2 e^{-\frac{2t}{SR}}}{12 \mu v c^2} dt = \frac{\frac{1}{2} S V_0^2 \cdot R}{12 \mu v c^2},$$

which must also equal $\frac{1}{2} S V_0^2$, the initial energy; hence

$$R = 12 \mu v c^2 = 360\, c^2 \text{ ohms.}$$

Taking as a numerical example the same oscillator as above, with $c = 4\frac{1}{2}$ and $V = 88$ electrostatic units, all these values are easily estimated. For instance, the mean energy of the radiation per unit volume at any considerable distance r, say two metres, in the equator, is

$$\frac{K V^2}{32\pi c^2 r^2} = \frac{88 \times 88}{25 \times 81 r^2} = \frac{3{\cdot}8}{r^2} = \frac{3{\cdot}8}{4 \times 10^4} \text{ barads}$$

= 95 microbarads, at a distance of two metres.

This will cause a momentary pressure on a metallic surface normally exposed to it of 95 microdynes per square centimetre, or a milligramme weight per square metre; and is nearly twice as strong as full sunshine while it lasts.

At one metre distance, I need hardly say, the energy and pressure are four times as great.

The area of energy absorbed by a fine wire linear receiver may be estimated roughly by finding the closeness of a grid of parallel wires which would just not let any radiation pass through it. Suppose, for instance, that a grid with wires 10 centimetres apart satisfies this condition; then each wire mops up energy for a breadth of five centimetres on either side of itself. The heat generated in such a wire at each spark is

$$\frac{3}{2} \cdot \frac{b l}{4\pi r^2} \cdot \frac{1}{2} S V_0^2$$

This, in the numerical case already taken, with $\frac{S}{K} = 1{\cdot}4$ centim. and $K V_0^2 = (88)^2$ dynes, gives, at a distance of one metre,

$$\frac{3 \times 500}{25 \times (100)^2} \times {\cdot}7 \times (88)^2 = 32{\cdot}5 \text{ ergs per spark};$$

which, repeated 100 times a second by a suitable contact-breaker, would yield 3,250 ergs per second, or one ordinary thermal unit every 3¼ hours.

The dissipation-factor, mentioned at the end of last section, is $e^{-\frac{100}{1{\cdot}4 \times 12 \times 81}}$.

Attempt at Further Detail.

To work out more completely what happens when one oscillator is used to excite another arranged parallel to it at an equatorial distance, r, not near enough to react, I suppose we may consider the receiver as subjected to an impressed E.M.F. given by (8), and write down the equation to its current x at any instant,

$$\ddot{x} + 2\kappa\dot{x} + n'^2 x = \frac{l' V_0}{2rc} e^{-mt} \sin(qr - pt) \quad . \quad . \quad (12)$$

the solution of which is given (for instance) in Lord Rayleigh's "Sound," vol. i., p. 62.

The heating of the receiver at each spark will be $\int_0^\infty R' x^2 \, dt$.

If there be two such receivers, far enough off each other not to encroach on each other's field, the current attraction between them will be proportional to $\dot{x}_1 \dot{x}_2$, and the static repulsion to $x_1 x_2$.

Calling the right-hand side of the above equation U, and writing $n'^2 - \kappa^2 = n^2$, the complete solution is

$$x = \frac{1}{n}\int_0^t e^{-\kappa(t-t')} \sin n(t-t') \,.\, U' \, dt'$$

$$+ \frac{x_0}{\cos} \,.\, e^{-\kappa t} \cos(nt - \gamma) \,; \quad . \quad . \quad . \quad . \quad . \quad (13)$$

where U′ is the same function of t' that U is of t, and where $\tan\gamma = \frac{x_0}{nx_0} + \frac{\kappa}{n}$.

The second term in the above, which expresses free vibrations in the receiver, may be made zero, because it contains the initial disturbance of the receiver as a factor, and the first term, which expresses forced vibrations, simplifies down to

$$x + C = \frac{l' V_0}{4nrc} \,.\, e^{-mt}\left(\frac{\sin\alpha}{p-n}\cos(qr - pt + \alpha) - \frac{\sin\beta}{p+n}\cos(qr - pt + \beta)\right) \quad . \quad . \quad . \quad . \quad (14)$$

where $\tan\alpha = \frac{p-n}{\kappa - m}$, and $\tan\beta = \frac{p+n}{\kappa - m}$.

If there is anything like agreement between the natural periods of vibrator and resonator, the first of these two terms overpowers the other.

Another way of writing the solution is

$$x + C = \frac{l' V_0}{4rcn} \,.\, \frac{\sin(\beta - \alpha)}{\kappa - m} e^{-mt} \,.\, \sin\, qr - pt + \alpha + \beta). \qquad (15)$$

Appendix.

It is in accordance with theory to assert that the action of two given magnets on each other varies inversely with the permeability of the medium; that the action of two currents on each other varies directly as the permeability of the medium; and that the action of a current on a given magnet is independent of the properties of the medium.

To avoid misunderstanding, it must be perceived that the statement refers to a given magnet, not to a magnet of numerically specified strength, because about that there would be some ambiguity according to the medium in which it was measured.

Similarly, the static action between two charges is inversely as the dielectric constant of the medium; the action between a given charge moving at the approximate light speed and a given magnet is independent of the medium, except in so far as its properties affect the velocity of light; while the dynamic action between two given charges moving together at the light speed is proportional to the permeability.

It may be as well to have direct experimental verification for some of these things.

CORRESPONDENCE.

RECKENZAUN'S IMPROVED METER.

To the Editor of The Electrical Engineer.

Sir,—I have noticed in this week's number a description of Reckenzaun's improved meter. It may interest this gentleman and others to know that the fundamental principles involved formed the subject of a patent granted to Messrs. Varley and Greenwood, as long ago as May 12, 1882, being numbered 2,248. Their claims, which are two in number, are as follows:

1. The improved apparatus, wherein the speed of the indicating mechanism is caused to vary with, and in proportion to, the current passing through the circuit, by means of a roller or wheel arranged to be brought into contact with different parts of the surface of a disc rotating at a uniform speed, as above set forth.

2. In the said apparatus, the employment of an electromagnet, a solenoid, or other suitable device for bringing the roller or wheel into contact with different parts of the surface of the disc, substantially as and for the purpose set forth.

One form of the Varley and Greenwood meter had a motor which actuated a clock movement, which in turn caused the disc to revolve at a uniform speed, and the only weak point in their combination was in the device for controlling the position of the wheel or roller on the face of the disc, so that the speed of the same was proportional to the current passing.—Yours, etc., Francis Teague.

Acme Electric Works, N.W., Nov. 6th.

RULE FOR ELECTRIC BELL AND ALARM WIRING.

To the Editor of the Electrical Engineer.

Sir,—From a letter in this week's *Electrical Engineer* I see that your correspondent, W. Perrem Maycock, is under the impression that he is forming some new rules as regards electric bells and wiring for these.

As one of the oldest electricians in this particular branch, allow me to state that I introduced some 25 years ago the following "rules," and which have since been strictly adhered to by all my employés:

A red wire for C. pole of battery.

A blue wire for Z. pole of battery.

All red wires to terminate at the bottom or small spring in all pushes.

All blue wires to terminate at the right-hand terminal of all bells.

As for return or line wires, no rules are required, as a workman who knows his business would not resort to testing to find in which direction the wires are running.

I may also state that I was the first one who introduced screwbacks into china push fronts; one of the first who covered electric bell wires with indiarubber strips, and used tinned copper wire instead of plain copper. I also introduced the system of being able to communicate with a travelling passenger lift by means of electric bells fixed in the cage.

I introduced the hotel cab-call, and various other useful inventions in connection with electric bells, all of which may be seen at the Langham Hotel, and where they have worked satisfactorliy for over seven years, and where over 900 bells are kept in action by a set of eight No. 2 Leclanché batteries.

Not wishing to trespass on your valuable space, and thanking you for giving publicity to the above in your next issue, yours, etc., Adam Koerber.

44, Frith-street, W., Nov. 8.

LIFE OF GLOW LAMPS ON THE SERIES SYSTEM.

To the Editor of the Electrical Engineer.

Sir,—In the discussion on Mr. Bernstein's paper on the "Series System," read in the Institution of Electrical Engineers in 1886, Mr. Mordey expressed the opinion that lamps on a circuit of constant current must of necessity be shorter lived than lamps on a parallel circuit; the reason being that the resistance of lamps rises in course of time. If placed in parallel they will then take less current, give less light, but have a considerable preservative power.

This view appears very plausible, and it will therefore be of interest to many readers to hear that a Bernstein lamp, which was placed on a circuit of constant current of 10 amperes in Niagara in London, has been in use more than three years every night except Sundays, and has already lasted more than 10,000 hours. During the present year it has been run 12 hours daily.

The system on which this lamp has been run is known as the Wood's system of arc lighting, and is owned by the Fort Wayne Electric Company, of Indiana.—Yours, etc.,

Frank Lott, electrical engineer in charge.

Niagara in London, Nov. 7, 1890.

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Specimen copies of the paper will be sent on request.

INFORMATION WANTED.

The action of the London Chamber of Commerce, or the Electrical Section of it, in attempting to initiate some method of gaining trustworthy data will present itself in different aspects to different people. When the millennium commences, this scheme may work, but till then it won't. In the first place, it must be considered that there are two classes of people—one that takes all the information it can get, and never by any chance imparts information; the other class gives a certain amount of information, withholding that which might benefit competitors. Without attempting at the present moment to discuss the scheme in its full bearings, let us consider one point. Why does the name of, say, Mr. Mansergh appear so frequently in the preparation of sewage schemes? Why does the name of Mr. Baker appear so frequently in bridgework? Why does the name of Mr. Moulton appear so frequently in legal technical cases, and so on through the whole of the industries or the professions? It is simply because the men who want a sewage scheme designed, or a bridge designed, or a legal case fought, go to the men whom they think have the greatest experience, and will be most likely to supply best just what is wanted. Of course, it is assumed that money is no object, and that the fees demanded are forthcoming, otherwise some other selection must be made. Now, if a man has by systematic perseverance, by his energy, by constant application, got to know somewhat more of his special subject than his competitors, then that man can command a higher price and altogether more lucrative and easier work than others. He is not going to put his competitors upon an equal footing with himself by "tipping" them with notes. If, then, we enquire too closely into Mr. Crompton's scheme, we shall find that in one or more directions it is an endeavour to put competitors upon the same footing. No competitors ever imagined themselves upon the same footing. Each believes that he has specialities that put him above his fellows, and that more work ought to come to him—his great difficulty is in getting the buying public to believe this. An electrical engineer applied to for designs for lighting would consult these statistics, see those relating to districts similar to the one he had in charge, and make his plans accordingly. In a few cases some originality would creep out, but not often. The statistics would say what boilers, engines, and dynamos to use, what method of distribution to adopt. A new dynamo would have no history, and would by the many be rejected because it was new. The introduction of anything new would be rendered more difficult than at present, for now men's minds are open, and engineers delight in getting the call of their competitors. There is a rough and ready way of getting a pretty good knowledge of

what goes on in company work, and of obtaining an absolutely accurate knowledge of "cost." The receipts of a company show amounts received for "energy" supplied. The expenditure shows the total cost of that "energy." It matters not whether the expenditure be in directors' fees or stokers' wages, it all goes to "cost of production"; and here the value of Mr. Crompton's idea, if completely carried out, would be immense. It would show shareholders where the leakage took place. That information is usually not what directors want shareholders to know. But we shall return again to the subject.

THE METROPOLITAN COMPANY.

A full report of this company's meeting will be found elsewhere. It is rather long, and seems to be more a conglomeration of inconsequential fair-weather statements than any real indication of the position of the company. Something of this kind must be a necessity, for, as yet, the company has been mostly engaged in spending capital upon installing central stations rather than obtaining income from working stations. So far the installation work has progressed favourably. The stations at Whitehall, Sardinia-street, Rathbone-place, and Manchester-square are in full swing. The immense development there is for the electric light will be realised from the fact that at the time of the last ordinary meeting the company had 58 customers, and supplied current for 15,000 lamps, while at the present time they have 300 customers with 40,000 lamps, and contracts in hand for a further 10,000 lamps. The rapidity of connecting with the stations is shown from the fact that in March 3,000 lamps were added to the system, in April 3,000, in May 2,000, in June 1,000, in July 7,000, in August 3,000, in September 3,000, and in October 4,000. The company intends to fully develop the work in hand before undertaking extensions—first, to prove the lighting a commercial success, and then come to the public for an extension of capital. The public should be pleased to find it, and will do so if the forecast proves true. The Whitehall station is calculated to supply a maximum of 8,000 lamps, it now supplies 5,000; Sardinia-street can supply 50,000, at present it supplies 19,500; Rathbone-place is not finished, when complete it will supply 21,000 lamps; Manchester-square supplies 11,000 lamps. It will most likely be noticed that the figures given by the chairman do not agree very closely, probably some of the details were not given. Thus we are told that the stations when fully equipped will give current for 114,000 lights. The details previously given do not state the maximum of Manchester-square, but the others will supply a total of 79,000—leaving a maximum for Manchester-square of 35,000, of which, as has been seen, 11,000 are connected.

The statements as to profits and probable profits were very crude. A small profit is got with 30,000 lights. How much more therefore, intimated the chairman, when 114,000 are connected. Taking the estimated revenue for the quarter at £10,000, which comes from an average of 35,000 lamps (seeing that the quarter ended with 40,000 lamps connected and began with 30,000), this gives a revenue per lamp of about 5·7 shillings, or about 22s. 9½d. per lamp per year, and each lamp is according to these figures supplied with about 37 units at 7½d. per unit. Now if we only knew the cost per unit we should know the profit or approximately so, and should be better able to judge what would be the profit on 114,000 lamps. The balance-sheet, when issued, will, however, give facts and not estimates.

RAILWAY READERS.

The effect of reading in railway carriages forms the subject of statistics in French medical journals and of a note in the *Lancet*. The suggestion made by the *Lancet* is one that commends itself to all travellers, and especially to electrical engineers. It is "that all carriages should, as a general rule, be supplied with a better light." The *Lancet* acknowledges that it is almost useless to expect travellers to stop reading. In many cases the exigencies of business compel train reading. A few companies have, in a half-hearted manner, acknowledged the claims of the travelling public for more light, and have replaced the antiquated oil lamps, which give a sufficient light (where it is not wanted) to make darkness visible, and a glimmer through a mass of oil floating at the bottom of the lamp in the direction of the travellers—these, we say, have been replaced, in a few instances, by gas with little better results, for the pressure is carefully regulated, so that the lamp merely burns feebly, and neither wastes the gas nor lights the carriage. Few and far between are the carriages lighted by electricity, but these few certainly do provide "more light" and enable a reader to read in comparative comfort. Managers of railways seem to lavish all their thoughts upon "long-distance trains" and relegate the old ramshackle carriages, dirty, mildewed, and moth-eaten, to the suburban ticket holders. No doubt there is much to admire in railway management, but, on the other hand, there is also much to grumble at.

LEAMINGTON.

It is a great pity that the authorities at Leamington and the electric light contractors cannot agree. We have already referred to the photometric tests made and reported on by the surveyor. A letter written by Messrs. Chamberlain and Hookham to the Watch Committee of the Corporation, and considered by that committee last week, seems to have

brought matters to a crisis. The ability to write smart and pungent letters is ofttimes a valuable possession, though at other times it serves only to set up backs. We do not know how far the exchange of letters has tended to irritate both sides at Leamington, yet it does seem peculiar that from first to last there have been bickerings. The position of matters is this: The Town Council instructed the town clerk not to pay the contractors' account. The latter now demand 5 per cent. upon the unpaid account, and give the Corporation six months' notice to terminate the contract. They dispute the accuracy of the surveyor's report regarding the tests, and intimate their intention to apply for a provisional order. The Corporation also are applying for a provisional order, so we have the unique phenomenon of a contractor in possession—and in possession originally with the consent of the local authority—now in antagonism to that body, and in future to compete for the good graces of the Board of Trade. There is no doubt as to the direction in which the provisional order will go, and if it does go to the Corporation, it also seems certain that the initial expense of the contractors must end in loss, unless the undertaking is taken over by the Corporation. The letter sent to the Watch Committee was reported to the Council on Monday last, and the report adopted. Here at present the matter ends.

BOMBAY.

SCHEDULE OF CONDITIONS FOR ELECTRIC LIGHTING.

Tenders are invited by the Municipal Commissioner for the City of Bombay for lighting by electricity the streets shown on the accompanying plan and also the interior of the Arthur Crawford Markets for a period of two years. [We shall hope to publish this plan next week.]

II. Tender must be submitted subject to the following conditions:

(I.) The contractors must supply and keep in repair and fix in position all materials required for the contract and must submit with their tender, plans and drawings of the post, standard, or column which they propose to use for (*a*) arc lights, (*b*) incandescent, and shall state fully in writing the material of which each is to be constructed and the mode of decorating or painting the same.

(II.) All cables and wires shall be underground and carried in such a way as to offer no danger whatever to the public. All circuits are to be completed by a return wire. The use of earth will not be allowed. A full description of the cable giving particulars as to nature of insulator, protection, or covering, method of laying, with sectional drawings, should accompany the tender.

(III.) An arc light shall be of 2,000 c.p. and shall be placed on a standard at a level of not more than 20ft. above the surface of the road.

(IV.) An incandescent light shall be of 32 c.p. and placed on a standard at a level of not more than 8ft. 6in. above the surface of the road.

(V.) The tender should state the class of circuit by which the lighting is to be carried out.

(VI.) It should be clearly stated whether the system will be

(*a*) High tension with or without transformers;
(*b*) Low tension; or
(*c*) What system it is proposed to adopt.

(VII.) The Municipality will provide sites for engine and dynamo house, also a free supply of water.

(VIII.) The distance between the incandescent lights is taken at 140ft., but the Municipal Commissioner will be prepared to consider proposals for placing them nearer or more distant if it can be shown that such a course would be advantageous to the public. The generating plant shall be put down in duplicate and so coupled up that the least possible delay may occur in starting spare machinery, whether engine, boiler, or dynamo.

(IX.) The general lighting is to be effected by incandescent lamps, but large open spaces, such as that around the Frere Fountain, will have to be provided with arc lights.

(X.) The lighting of the streets will be regulated according to the state of the moon, for which a schedule will be issued monthly, showing the hours for lighting and extinguishing, but the total number of hours for which such lights must be lighted during the year shall be determined to be 3,073·5.

(XI.) Three incandescent lamps in Church Gate-street and three at Apollo Bandar shall be lighted every night and shall be burnt for not less than 3,869 hours during the year.

(XII.) The following is a list of the streets and the proposed number of incandescent lamps required in each:

	Incandescent lamps.
1. Arthur Crawford Market to Church Gate-street	80
2. Church Gate-street to Apollo Bandar	70
3. Money School (Dhobi Talao) to Church Gate-street	59
4. Church Gate-street and Elphinstone Circle	32
	—241

(XIII.) The following is a list of arc lights proposed for the undermentioned localities, indicated on the plan by a star:

	Arc lights.
1. Arthur Crawford Markets	16
2. Opposite Arthur Crawford Markets	1
3. Opposite Victoria Terminus	4
4. Around Frere Fountain	2
5. Prince of Wales's Statute	1
6. At Wellington Fountain	2
7. Apollo Bandar	7
8. Queen's Statue	3
9. Money School (Dhobi Talao)	2
10. Junction of Paltan and Hornby roads	1
	—39

The tender must be accompanied by a deposit of Rs. 1,000 in cash or Indian Public Security, the same to be forfeited on refusal to sign the contract. A further payment, amounting in all to 5 per cent. of the total contract amount, will be required should the Municipal Commissioner accept the tender.

Tenders must be submitted not later than 1 p.m. on Monday, the 16th February, 1891, addressed to

H. A. ACWORTH, Esq., C.S.
Municipal Commissioner for the City of Bombay,
Bombay, India.

FORM OF TENDER.

.... hereby undertake to provide electric light for a period of two years at the positions indicated on the accompanying plan, in accordance with the conditions included in the attached schedule of conditions at the following rates:

Per arc light of 2,000 c.p. per 3,073·5 hours distributed over a period of 365 days .... Rs.........
Per incandescent lamp of 32 c.p. per 3,073·5 hours distributed over a period of 365 days... Rs.........
Per incandescent lamp per 3,869 hours distributed over a period of 365 days .... Rs.........
Per arc light of 2,000 c.p. for Arthur Crawford Market per year of 1,008 hours or at the rate of 84 hours per month .... Rs.........
Per arc light of 2,000 c.p. for Arthur Crawford Markets per year of 1,920 hours or at the rate of 160 hours per month .... Rs.........

The schedule of conditions and the plan showing the positions of the lamps have been signed by .... in token of .... acquiescence with the conditions and positions contained therein.

The system to be employed by .... will be ....

The tension will be .... The circuit will be ....

All wires, cables, etc., will be underground.

.... undertake to complete all the works required by the .... day of .... 189 , and to have the whole installation lighted by ...... day of .... 189 .

.... have this day deposited as earnest money with the chief accountant of the Municipality the sum of rupees one thousand in cash, not to bear interest,* or the equivalent of rupees one thousand in public securities,† and...... do hereby agree that this sum shall be absolutely forfeited by .... if, in the event of this tender being accepted, ... fail to deposit a further sum in public securities, making up, with the amount already deposited, a sum equivalent to 5 per cent. of the total amount of .... contract (calculated on the basis of .... tendered rates for the number of lights mentioned in the said schedule of conditions) as security money for the faithful performance of the contract, or .... fail to execute the formal contract or agreement embodying all the conditions and terms of the said schedule of conditions, and also any other conditions which may be mutually agreed upon between the Municipal Commissioner and ....

.... hereby further agree to pay all the charges of whatsoever nature in connection with the preparation and execution of the said contract or agreement, and also to pay all the charges for the safe custody and withdrawal of, and for the collection of interest on, the security money deposited, or which may hereafter be deposited by ...., as herein above provided, and that all such charges may be deducted out of any moneys payable to .... under this or any other contract between .... sel ...... and the Municipality.

...... have the honour to be, Sir,
Your most obedient servant...,

Address............

NEW MAGNETIC CUT-OUT.

A new magnetic cut-out is shown in the accompanying illustrations, Fig. 1 representing the position of the parts

Fig. 1.

when the circuit is closed, and Fig. 2 when it is broken.

* Tenderers are to strike out such words as do not apply.

† Securities of the Government of India and any securities guaranteed by such Government, securities of the Bombay Port Trust, securities issued under the City of Bombay Act, 1888, and municipal debentures or other securities of the Municipality of Bombay.

The ends of the horizontal copper bridge piece shown com Fig. 2. Thus the contacts are removed from the mercury cups and the circuit is broken. This cut-out has been designed by Mr. Napier Prentice, of Stowmarket, Suffolk, plete the circuit between the mercury cups; but when the current rises abnormally, the armature of the electro-magnet is attracted. This causes the cross-piece to move the vertical lever into such a position that its weighted head makes it suddenly fall over so that its tail end kicks the bridge and knocks it over into the position shown in

Fig. 2.

and is said not to be affected by the formation of oxide of mercury.

CROYDON LIGHTING.

REPORT BY MR. W. H. PREECE, F.R.S.

The Croydon Town Council have decided, on the recommendation of their General Purposes Committee, and influenced by the following report from Mr. Preece, to apply for an order. Mr. Preece recommends the high-pressure alternate-current system, with a central station at the water works, and transformer stations at Upper Norwood, South Norwood, Thornton Heath, and South Croydon. Underground mains are to be laid between the central station and these sub-stations; and from the sub-stations current is to be distributed partly underground and partly overhead. He proposes to replace the whole of the 1,781 gas lamps by electricity. Taking the population of the borough at 100,000, he estimates that the Council might consider that ultimately 30,000 lamps would probably be installed and used in the district. To work these it would be necessary to employ a capital of £150,000. As at first the lamps would only be taken up slowly, he does not think it would be necessary to call up a larger capital than £50,000 to start with, nor that during the first two years the Council could reckon upon fixing more than 3,400 lamps for public lighting, and 3,000 lamps for private lighting, a total of 6,400. Experience in other districts has shown, says Mr. Preece, that the Council might fairly estimate a revenue of 24s. 6d. per lamp per annum for private lighting, and as they are already paying £6,187 per annum for public lighting, he believes that they could regard this sum in the shape of revenue. He estimates for revenue:

3,000 private lamps (at 24s. 6d.)	£3,675
Present cost of public lamps	6,187
Total........	£9,862

He calculates that the working expenses would be 18s. per lamp per annum, which represents for the 6,400 lamps a charge of £5,760. The Council would thus have a balance of £4,102 to pay interest on money borrowed, and to go towards the reduction of the present rates. The public lighting would be much more efficient than at present. The electric lamps actually used would not be the standard lamps of 16 c.p., but mostly lamps of 32 c.p., and in some cases perhaps lamps of 50 c.p. Altogether the public lamps would be equivalent to 3,400 standard lamps. For private lighting, the number of lamps installed per house averages 40, but the number maintained alight averages only 20. In his opinion it would be better to take 20 for estimation. This would mean that the 3,000 lamps would be taken up by 150 houses; and this was the basis upon which the above estimate had been formed, and he did not think it was too sanguine.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

LECTURE II.

(*Continued from page 416.*)

We are now in a position to understand the bearing of some curious and important researches made about 40 years ago by Dr. Julius Dub, which, like a great many other good things, lie buried in the back volumes of Poggendorff's *Annalen*. Some account of them is also given in Dr. Dub's now obsolete book, entitled "Elektromagnetismus."

The first of Dub's experiments to which I will refer relates to the difference in behaviour between electromagnets with flat and those with pointed pole ends. He formed two cylindrical cores each 6in. long, from the same rod of soft iron, 1in. in diameter. Either of these could be slipped into an appropriate magnetising coil. One of them had the end left flat, the other had its end pointed, or rather it was coned down until the flat end was left only ½in. in diameter, possessing therefore only one-fourth of the amount of contact surface which the other core possessed. As an armature there was used another piece of the same soft iron rod, 12in. long. The pull of the electromagnet on the armature at different distances was carefully measured, with the following results:

Distance apart in inches.	Pull on flat pole (lb.).	Pull on pointed pole (lb.).
0	3·3	5·2
0·0055	1·1	1·8
0·0110	0·9	0·75
[illegible]	0·71	0·50
0·022	0·60	0·42
0·044	0·38	0·20
0·088	0·19	0·09

These results are plotted out in the curves in Fig. 35. It will be seen that in contact, and at very short distances, the reduced pole gave the greater pull. At about 10 mils distance there was equality, but at all distances greater than 10 mils the flat pole had the advantage. At small distances the concentration of magnetic lines gave, in accordance with the law of traction, the advantage to the reduced pole. But this advantage was, at the greater distances, more than outweighed by the fact that with the greater widths of air gap the use of the pole with larger face reduced the magnetic reluctance of the gap and promoted a larger flow of magnetic lines into the end of the armature.

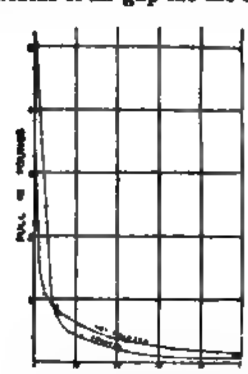

FIG. 35.—Contrasted Effect of Flat and Pointed Poles.

FIG. 37.—Dub's Deflection Experiment.

Dub's next experiment relate to the employment of polar extensions or pole-pieces attached to the core. These experiments are so curious, so unexpected, unless you know the reason why, that I invite your especial attention to them. If an engineer had to make a firm joint between two pieces of metal, and he feared that a mere attachment of one to the other was not adequately strong, his first and most natural impulse is to enlarge the parts that come together—to give one, as it were, a broader footing against the other. And that is precisely what an engineer, if uninstructed in the true principles of magnetism, would do in order to make an electromagnet stick more tightly on to its armature. He would enlarge the ends of one or both. He would add pole-pieces to give the armature a better foothold. Nothing, as you will see, could be more disastrous. Dub employed in these experiments a straight electromagnet having a cylindrical soft iron core 1in. in diameter, 12in. long; and as armature a piece of the same iron, 6in. long. Both were flat-ended. Then six pieces of soft iron were prepared of various sizes to serve as pole-pieces. They could be screwed on at will either to the end of the magnet core or to that of the armature. To distinguish them we will call them by the letters, A, B, C, etc. Their dimensions were as shown in Table A, the inches being presumably Bavarian inches.

Of the results obtained with these pieces we will select eight (Table B). They are those illustrated by the eight collected sketches in Fig. 36. The pull required to detach was measured, also the attraction exerted at a certain distance apart.

* Cantor lectures, delivered before the Society of Arts.

TABLE A.

Piece.	Diameter.	Length.
	inches.	inches.
A	2	1
B	1⅝	1¼
C	1⅜	2
D	2	½
E	1¼	1
F	1	2

TABLE B.

Experiment.	On magnet.	On armature.	Traction.	Attraction.
I.	none	none	48	22
II.	D	none	30	10
III.	E	none	32	11·5
IV.	C	none	35	13·5
V.	D	A	20	7·5
VI.	none	B	50	25
VII.	none	D	43	25
VIII.	none	C	50	18

It will be noted that, in every case, putting on a pole-piece to the end of the magnet diminished both the pull in contact and the attraction at a distance. It simply promoted leakage and dissipation of the magnetic lines. The worst case of all was that in which there were pole-pieces both on the magnet and on the armature. In the last three cases the pull was increased, but here the enlarged piece was attached to the armature, so that it helped those magnetic lines which came up into it to flow back laterally to the bottom end of the electromagnet, while thus reducing the magnetic reluctance of the return path through the air, and so increasing the total number of magnetic lines, did not spread unduly those that issued up from the end of the core.

The next of Dub's results relate to the effect of adding these pole-pieces to an electromagnet 12in. long, which was being employed, broadside on, to deflect a distant compass needle, Fig. 37.

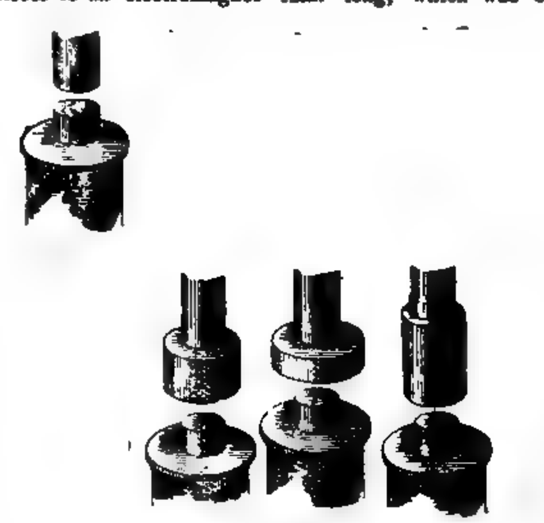

FIG. 36.—Dub's Experiments with Pole-pieces.

Pole-piece used.	Deflection (degrees).
None	34·5
A	42
B	41·5
C	40·5
D	41
E	39
F	38

In another set of experiments of the same order a permanent magnet of steel, having poles, *n s*, was slung horizontally by a bifilar suspension, to give it a strong tendency to set in a particular direction. At a short distance laterally was fixed the same bar electromagnet, and the same pole-pieces were again employed. The results of attaching the pole-pieces at the rear end are not very conclusive; they slightly increased the deflection. But in the absence of information as to the distance between the steel magnet and the electromagnet, it is difficult to assign proper values to all the causes at work. The results were:

Pole-piece used.	Deflection (degrees).
None	8·5
A	9·2
B	9·5
C	10
D	8·8

When, however, the pole-pieces were attached to the distant end of the electromagnet, where their effect would undoubtedly be to promote the leakage of magnetic lines into the air at the front end

without much affecting the distribution of these lines in the space in front of the pole, the action was more marked.

Pole-piece used.	Deflection (degrees).
None	8·5
A	10·0
B	10·3
C	10·3
F	10·1

Still confining ourselves to straight electromagnets, I now invite your attention to some experiments made in 1862 by the late Count Du Moncel as to the effect of adding a polar expansion to the iron core. He used as his core a small iron tube, the end of which he could close up with an iron plug, and around which he placed an iron ring which fitted closely on to the pole. He used a special lever arrangement to measure the attraction exercised upon an armature distant in all cases one millimetre from the pole. The results were as follows:

—	Without ring on pole.	With ring on pole.
Tubular core alone	11	10
Ditto with iron plug	17	14
Core provided with mass of iron at distant end	27	25
Ditto ditto with iron plug	38	33

After hunting up these researches, it was extremely interesting to find that so important a fact had not escaped the observant eye of the original inventor of the electromagnet. In Sturgeon's "Experimental Researches" (p. 113) there is a footnote, written apparently about the year 1832, which runs as follows:

"An electromagnet of the above description, weighing 3oz., and furnished with one coil of wire, supported 14lb. The poles were afterwards made to expose a larger surface by welding to each end of the cylindric bar a square piece of good soft iron, with this alteration only, the lifting power was reduced to about 5lb., although the magnet was annealed as much as possible."

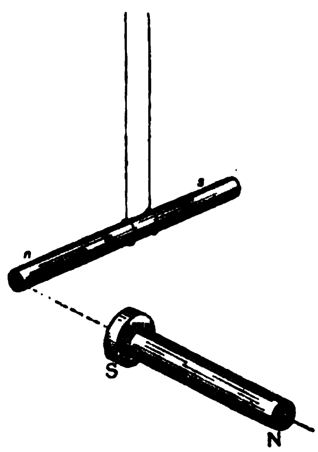

FIG. 38.—Deflecting a Steel Magnet having Bifilar Suspension, Pole-piece on Near End.

We saw that this straight electromagnet, whether used broadside-on or end-on, could act on the compass needle at some distance from it, and deflect it. In those experiments there was no return path for the magnetic lines that flowed through the iron core save that afforded by the surrounding air. The lines flowed round in wide-sweeping curves from one end to the other, as in Fig. 26, the magnetic field being quite extensive. Now, what will happen if we provide a return path? Suppose I surround the electromagnet with an iron tube of the same length as itself, the lines will flow along in one direction through the core, and will find an easy path back along the outside of the coil. Will the magnet thus jacketed pull more powerfully or less on that little suspended magnet? I should expect it to pull less powerfully; for if the magnetic lines have a good return path here through the iron tube, why should they force themselves in such a quantity to a distance through air in order to get home? No, they will naturally return short back from the end of the core into the tubular iron jacket. That is to say, the action at a distance ought to be diminished by putting on that iron tube outside. Here is the experiment set up. And you see that when I turn on the current my indicating needle is scarcely affected at all. The iron jacket causes that magnet to have much less action at a distance. Yet I have known people who actually proposed to use jacketed magnets of this sort in telegraph instruments and in electric motors, on the ground that they give a bigger pull. You have seen they produce less action at a distance across the air, but there yet remains the question whether they give a bigger pull in contact? Yes, undoubtedly they do; because everything that is helping the magnetism to get round to the other end increases the goodness of the magnetic circuit, and therefore increases the total magnetic flux.

We will try this experiment upon another piece of apparatus, one which has been used for some years at the Finsbury Technical College. It consists of a straight electromagnet set upright in a base board, over which is erected a light gallows of wood. Across the frame of the gallows goes a winch, on the axle of which is a small pulley with a cord knotted to it. To the lower end of the cord is hung a common spring balance, from the hook of which depends a small horizontal disc of iron to act as an armature. By means of the winch I lower this disc down to the top of the electromagnet. The current is turned on. The disc is attracted. On winding up the winch I increase the upward pull until the disc is detached. See, it required about 9lb. to pull it off. I now slip over the electromagnet, without in any way attaching it, this loose jacket of iron—a tube, the upper end of which stands flush with the upper polar surface. Once more I lower the disc, and this time it attaches itself at its middle to the central pole, and at its edges to the tube. What force will now be required to detach it? The tube weighs about ½lb., and it is not fixed at the bottom. Will 9½lb. suffice to lift the disc? By no means. My balance only measures up to 24lb., and even that pull will not suffice to detach the disc. I know of one case where the pull of the straight core was increased 16-fold by the mere addition of a good return path of iron to complete the magnetic circuit. It is curious how often the use of a tubular jacket to an electromagnet has been reinvented. It dates back to about 1850, and has been variously claimed for Romershausen, for Guillemin, and for Fabre. It is described in Davis's "Magnetism," published in Boston in 1855. About 16 years ago Mr. Faulkner, of Manchester, revived it under the name of the *Altandae* electromagnet. A discussion upon jacketed electromagnets took place in 1876 at the Society of Telegraph Engineers; and in the same year, Prof. Graham Bell used the same form of electromagnet in the receiver of the telephone which he exhibited at the Centennial Exhibition. But the jacketed form is not good for anything except increasing the tractive power. Jacketing an electromagnet which already possesses a return circuit of iron is an absurdity. For this reason the proposal made by one inventor to put iron tubes outside the coils of a horseshoe electromagnet is one to be avoided.

We will take another paradox, which equally can be explained by the principle of the magnetic circuit. Suppose you take an iron tube as an interior core; suppose you cut a little piece off the end of it, a mere ring of the same size. Take that little piece and

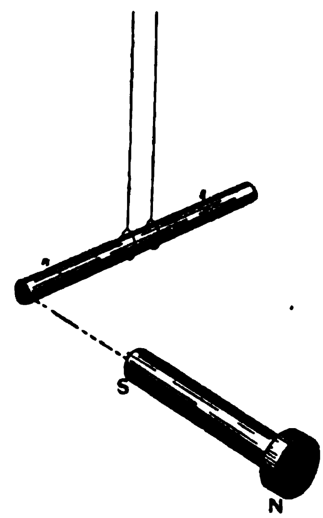

FIG. 39.—Deflecting Steel Magnet, Pole-piece on Distant End.

lay it down on the end. It will be struck with a certain amount of pull. It will pull off easily. Take that same round piece of iron, put it on edgewise, where it only touches one point of the circumference, and it will stick on a good deal tighter, because it is there in a position to increase the magnetic flow of the magnetic lines. By concentrating the flow of magnetic lines over a small surface of contact increases B at that point, and B^2, integraded over the lesser area of the contact, gives a total bigger pull than is the case where the edge is touched all round against the edge of the tube.

Here is a still more curious experiment. I use a cylindrical electromagnet set up on end, the core of which has at the top a flat circular polar surface about 2in. in diameter. I now take a round disc of thin iron—ferrotype or tinplate will answer quite well—which is a little smaller than the polar face. What will happen when this disc is laid down flat and centrally on the polar face? Of course, you will say that it will stick tightly on. If it does so, the magnetic lines which come in through its under surface will pass through it and come out on its upper surface in large quantities. It is clear that they cannot all, or even any considerable proportion of them, emerge sideways through the edges of the thin disc, for there is not substance enough in the disc to carry so many magnetic lines. As a matter of fact, the magnetic lines do come through the disc, and emerge on its upper surface, making, indeed, a magnetic field over its upper surface that is nearly as intense as the magnetic field beneath its under surface. If the two magnetic fields were exactly of equal strength the disc ought not to be attracted either way. Well, what is the fact? The fact, as you see now that the current has been turned on, is that the disc absolutely refuses to lie down on the top of the pole. If I hold it down with my finger it actually bends itself up, and requires force to keep it down. I lift my finger, and over it flies. It will go anywhere in its effort to better the magnetic circuit rather than lie flat on the top of the pole.

Next I invite your attention to some experiments, originally

due to Von Kolke, published in the *Annalen* 40 years ago, respecting the distribution of the magnetic lines where they emerge from the polar surface of an electromagnet. I cannot enumerate them all, but will merely illustrate them by a single example. Here is a straight electromagnet, with a cylindrical, flat-ended core, Fig. 41. In what way will the magnetic lines be distributed over at the end? Fig. 41 illustrates roughly the way in which, when there is no return path of iron, the magnetic lines leak through the air. The main leakage is through the ends, though there is some at the sides also. Now the question of the end distribution we shall try by using a small bullet of iron, which will be placed at different points from the middle to the edge, a spring balance being

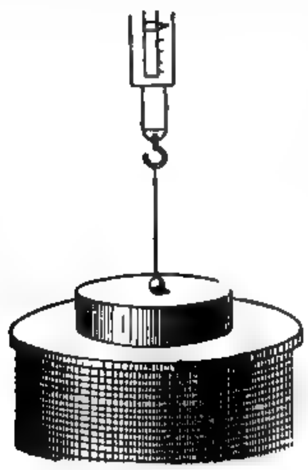

FIG. 40.—Experiment with Tubular Core and Iron Ring.

FIG. 41.—Exploring Polar Distribution with Small Iron Balls.

employed to measure the force required to detach it. The pull at the edge is much stronger than at the middle—at least four or five times as great. There is a regular increase of pull from the middle to the edge. The magnetic lines, in trying to complete their own circuit, flow most numerously in that direction where they can go furthest through iron on their journey. They leak out more strongly at all edges and corners of a polar surface. They do not flow out so strongly at the middle of the end surface, otherwise they would have to go through a larger air circuit to get back home. The iron is consequently more saturated round the edge than at the middle; therefore, with a very small magnetising force, there is a great disproportion between pull at the middle and that at the edges. With a very large magnetising force you do not get the same disproportion, because, if the edge is already far saturated you cannot by applying higher magnetising power increase its magnetisation much, but you can still force more lines through the middle. The consequence is, if you plot out the results of a succession of experiments of the pull at different points, the curves obtained are, with larger magnetising forces, more nearly straight than are those obtained with small magnetising forces. I have known cases where the pull at the edge was six or seven times as great as in the middle with a small magnetising power; but with larger power not more than two or three times as great, although, of course, the pull all over was greater. You can easily observe this distribution by merely putting a polished iron ball upon the end of the electromagnet, as in Fig. 42. The ball at once rolls to the edge, and will

FIG. 42.—Iron Ball attracted to Edge of Polar Face.

not stay at the middle. If I take a larger two-pole electromagnet (like Fig. 11) what will the case now be? Clearly, the shortest path of the magnetic lines through the air is the path just across from the edge of one polar surface to the edge of the other between the poles. The lines are most dense in the region where they arch over in as short an arch as possible, and they will be less dense along the longer paths, which arch more widely over. Therefore, as there is a greater tendency to leak from the inner edge of one pole to the inner edge of the other, and less tendency to leak from the outer edge of one to the outer edge of the other, the biggest pull ought to be on the inner edges of the pole. We will now try it. On putting the iron ball anywhere on the pole it immediately rolls until it stands perpendicularly over the inner edge.

The magnetic behaviour of little iron balls is very curious. A small round piece of iron does not tend to move at all in the most powerful magnetic field if that magnetic field is uniform. All that a small bar of iron tends to do is to move from a place where the magnetic field is weak to a place where the magnetic field is strong. Upon that fact depends the construction of several important instruments, and also certain pieces of electromagnetic mechanism.

(To be continued.)

INDUSTRIALISM.*

BY W. R. ESSON.

(Concluded from page 412.)

But, along with improved methods of production, there has grown up within the century that vast distributive system which is represented by a railway capital of nearly one thousand millions sterling, and the direct employment of nearly half a million workmen. When we remember that these have to be fed, and clothed, and housed; when we recollect that a large number of workmen must be employed in providing the iron and steel required in the manufacture of rolling-stock, and that materials and labour must be constantly forthcoming for the construction of lines in progress; when we perceive that this distributive system, rendered necessary by increased production, has in its turn stimulated production to an incalculable extent, we begin to realise, though but faintly, how far-reaching in its influence on industry railway progress has been. Then we have—as constituting a farther means of distribution—docks, in the construction of which millions have been expended, and a huge mercantile navy which, by the direct and indirect employment of armies of workmen, enable us to effect an advantageous exchange of our goods for those of other nations. Ships have to be built, and workmen have to be supplied with the means of life in return for their labour. The raw materials must be furnished, and the necessary iron and steel produced by another host of labourers. Nor is this all, for outside the artisan classes indirectly depending on distribution for a livelihood, are thousands employed in mercantile houses, shipping agencies, and brokers' offices, all occupied in effecting the distribution of commodities, not to speak of the hundreds of thousands engaged in wholesale warehouses and retail shops. Meditating on these things, I say we begin to comprehend how vast, how complex, how inter-dependent in all its ramifications industrialism has become.

But how does this affect the workman himself? Well, generally he works shorter hours than ever he did, and the purchasing power of the wage he receives is higher than ever. Individually or in combination with others, he is free to bargain with his employer for the price of his labour, and nobody interferes. Yet that he is far from satisfied with his lot, is a matter of daily observation. That the employer is displeased with his profits is also made manifest. That both fail to adjust their differences amicably is a fact which continues to be emphasised by constantly recurring strikes and locks out. In June of this year, for example, there were 79 strikes recorded, in July there were 99, and in August the number rose to 105. Some of these were of considerable magnitude and importance. The dock labourers and seamen headed the list with 16. The cotton trades come next with 15; the building trades follow with 12 and the miners with nine, the remainder being divided among the miscellaneous trades. Since then strikes in the iron and shipbuilding trades have been rife. As I write† a strike in the tin-plate trade has just terminated, battalions of troops are held in readiness at Chatham to quell disturbance should the Beckton gas stokers strike, news comes that for the first time in the history of our iron manufacture all the Scotch furnaces, with the exception of those at Carron and Wishaw, are out of blast, the furnacemen having struck work. It must be remembered that each strike or lock-out is a confession of failure on the part of employers' associations or men's unions to adjust their differences in a reasonable spirit. These combinations exist for the purpose of settling labour disputes peaceably. A strike or lock-out is the last resource of either, and when this has taken place employer and employed stand related to each other as do two nations who, after vainly attempting to come to terms in the council chamber or refusing to submit to arbitration, determine to meet in the battle-field. The industrial battle, though generally a bloodless one, is inevitably disastrous which ever side gains, and these violent methods of settling disputes can only be regarded as constituting a virulent disease to which the industrial organism in its present stage of development is exceedingly liable. Nor can disease seize on one part of the system without producing, to a greater or less extent, functional derangement throughout the whole. A strike amongst the blast furnacemen, for instance, while it reduces the output of iron, throws upon the market a quantity of coal which, before the strike, was used in smelting. This will make prices fall, and if the strike were long continued, would probably lead to a reduction of the miners' wages. Again, if the demand for iron keeps up, the price will rise as stocks are exhausted, and the price of manufactures in which iron and steel are employed will rise accordingly. Owing to the rise, the demand in the shipbuilding and other iron-using industries will fall off, and the wages of those engaged in them may be in turn reduced. Of course I don't say that all these things will inevitably occur. What I mean is that the strike creates

* Presidential address delivered to the Old Students' Association of the City and Guilds of London Institute at Finsbury College, November 6, 1890.

† October 5th.

forces tending to make them happen, and which, if applied for a sufficiently long period, would doubtless have the result indicated. I use this illustration to show that every branch of industry hangs, as it were, upon another. Men think they are fighting the capitalist, when they are really fighting the workmen in a different branch of trade as well, and endeavouring to obtain a rise of wages partially at their expense. Emphasising this very point, there comes, while I write, the news that a thousand men are locked out in the engineering works at Newport, owing to a dispute between the smiths and boiler-makers.* As a matter of fact, profits and wages are derived from the same fund, employer and employed alike endeavouring to make the shares they respectively receive as large as possible.

Then outside the region of skilled labour, to which the observations in preceding paragraphs are mostly applicable, is a host of unskilled workmen, whose condition in many cases is, to say the least, precarious. Towards the docks and the East-end drift this flotsam and jetsam of labour, and the attempts, successful to some extent, to form the dockers at different ports into a compact combination capable of bargaining for its services *en masse*, will be fresh in your memories. In the organised branches of this labour, however, strike has followed strike for the past 12 months in rapid succession. The Southampton riots are an affair of a month ago, and to-day steamers are lying in the London docks with grain cargoes which corn porters refuse to unload, notwithstanding the advice of their union leaders to the contrary. The right of men to strike is admitted. The principle of free labour is that if a man is dissatisfied he is at liberty to leave work and make a better bargain for his labour elsewhere. But while admitting the right, it is quite another question whether this right is being exercised to advantage or disadvantage. It seems here that the men have got quite beyond the control of the union officers. Intoxicated with success, they seem to think that there are no extremes to which they may not go. They are like an army which, in the triumph of victory, exhibits insubordination, becomes disorganised, and falls an easy prey to an enemy on the watch for advantages.

That strikes are a blot on industrialism is admitted by all, nor is evidence wanting to show that they are conducted frequently in that spirit of militancy which is inherited from more barbarous ages. Coercion and intimidation are frequently resorted to. Rioting is common, and the strikers when arguing with the recalcitrant "blackleg" are not averse to occasionally emphasising the chief points by the aid of sticks or crowbars. In fact, gentlemen, we have in the conduct of a modern strike the old aggression appearing—we have the persecution, the intolerance, and the oppression bred in our benes made manifest—we have all the evil of the human nature of our time revealed, which only the discipline of centuries to come can thoroughly eradicate.

But outside organisation of any kind is a shiftless throng of humanity living in rookeries, degraded, ill-clad, and worse fed. It is almost impossible for us to conceive how these creatures exist. As you know, competition is blamed for much of the evil in the East-end, and a sweating commission investigated the conditions under which the poor live but a short time ago. After collecting information regarding their lives from all sources, the commission issued a bulky report, which is practically bare of suggestion. It is, in short, an acknowledgment that for the precarious wages and the state of misery revealed the Legislature can offer no remedy. Irremediable though it may be, however, it is still a blot on the industrial system.

But trade disputes, inadequate wages, and poverty are not the only blots observable. Writing of Glasgow, 50 years ago, a writer remarked that every Saturday, and for the most part of Sunday, 10,000 or 20,000 workmen were more or less intoxicated, every farthing which could be spared being too often converted into ardent spirits. "The same individuals who a year before were reduced to pawn their last shreds of furniture to procure subsistence recklessly threw away the surplus earnings of more prosperous times in the lowest debauchery. The warnings of religion, the dictates of prudence, the means of instruction, the lessons of adversity, are alike overwhelmed by the passion for momentary gratification."† That was written in 1840, but it is fairly true to-day. Anyone who studies closely the habits of the labouring classes in our large towns cannot fail to be struck with the truth of Mr. Alison's observations. Improvidence, extravagance, and intemperance are the besetting sins of the British workman. "Very few of them lay by in anticipation of times when work is slack; and the general testimony is that higher wages commonly result only in more extravagant living or in drinking to greater excess." From personal experience of workmen, I should say that in the large towns of England there is spent on an average from 15 to 20 per cent. of the earnings on beer and tobacco. Providence plays but an unimportant part in their lives. They listen to the voice of instinct and follow the promptings of unregulated desire, but for the most part lack that power of self-denial which should enable them to sacrifice present enjoyment in order to obtain future benefit. I speak of them now as a class, but that there are many exceptions to this general rule goes without saying. Nevertheless, it will be observed that the labourers' grievances are largely of their own creation. Though they talk much of co-operation, they continue to pour the possible capital down their throats or blow it in the air.

Here, then, is the position of things. The units composing the industrial community are exceedingly imperfect, consequently the present industrial system works imperfectly, production being hampered by continual bickerings, not only between employer and employed, but between the various sections of the latter as well.

* October 6th.

† Mr. Alison on "Population," vol. i., page 290.

The earnings of industry after paying rent and taxes are divided into two parts, one payable to the capitalist for the loan of his capital, interest, the remainder constituting a wages and profits fund, which is divided between the managers and the workmen. So far as can be made out, it is the contention of the workman that the latter fund is unfairly divided, and in one or two words we may examine the conditions which regulate the division. First, however, it is necessary that the amount payable as interest be confused in no way with the amount divisible as earnings of management and earnings of labour among the producers. Though the same individual may be capitalist and manager, as often happens, the sums payable as interest and as earnings of management are to be considered quite separately. The amount due to interest is represented by the sum which the employer would get for the use of his capital if it were lent to a business man who managed a concern of the same kind as his own and having similar risks, is determined, in fact, by the market price of capital. This, as everyone knows, depends upon the demand for the use of money and the risk attending the lending of it. A corporation whose security is excellent can borrow readily at from 3 to 3½ per cent. But where there are various risks involved, as in most trading concerns, the borrowers have to raise money on mortgage debentures at 4½ to 5 per cent. Let it be understood that the capitalist has not fixed the amount of interest. That has been fixed by the competition for the aid of capital and the conditions under which it is lent. If the demand for the use of money is great, interest is forced up; if it gets less, interest falls. I conceive that the workman's objections are not to the interest the employer as a capitalist receives, but to the profits or, more properly, "earnings of management" which he takes from the wages and profits fund. Indeed, the workman by placing his savings in the bank may himself become a capitalist to the extent of his means, and get paid for the use of his money.

The amount due to interest being deducted, then, the wages and profits fund remains to be divided amongst the producers. You are no doubt familiar with the saying that the amount of wages received by any particular section of the community is regulated by the supply of, and demand for, their particular kind of labour. But that there are secondary forces coming into action which, in conjunction with supply and demand, are beginning to exercise an important influence on the rate of wages must be apparent to all who have watched recent labour movements. "In an industrial conflict," said Prof. Marshall recently, "each side cares for the opinion of the public at large, but especially for that of those whose sympathy they are most likely to get; in the South Wales strike, for instance, the railway companies were specially anxious about the good opinion of the shippers and the engine drivers about that of the colliers."* Thus we see that in addition to the influence of supply and demand the influence of public opinion is being brought to bear on questions relating to the adjustment of wages or to the distribution, if I might better put it, of the net industrial returns. Supply and demand are, however, the great regulators, and upon these mainly the adjustment of wages depends. The capitalist is outside this adjustment. It is effected by competition among the various sections of workers for different kinds of labour; and the higher wages offered to any particular branch when the labourers become scarce in it form the inducement for others to come in, thus increasing the supply, and tending to bring the wages down to their normal level. Managers and business men are not exempt from the universal competition. If business power is scarce a proportionally larger amount is paid for management out of the wages and profits fund, and, *ceteris paribus*, less remains for the time being for division amongst other workers; if business power is plentiful, proportionally less is paid, and the workers temporarily benefit. If the employer is capitalist and manager at the same time, the relation still holds good. True, he may pocket an apparently large sum as earnings of management, but, on the other hand, his enterprise, energy, ability, and fertility of resource have to be paid for.

It is a common saying that a large return means a great risk, and in the case of businesses making large profits, the employer's share may very often be regarded either as the reward of genius and foresight, or as the higher interest he obtains for his capital under the exceptional risk of losing it. Competition between manufacturers in an ordinary way, however, is constantly tending to reduce earnings of management, and in bad times an employer, who is manager and capitalist as well, has very often to endure all the trouble and worry of managing his business for nothing, gaining, in the end, merely a bare interest for his money, such as could be obtained without trouble by lending it to someone else. In a joint stock concern, the business is conducted by a manager and board of directors, who both receive wages of management, the capital being furnished by the shareholders. The latter receive a return as interest, and if this rises above the market rate, there are forces applied at once to bring it down to the normal in the form of new companies starting in the same business and entering into competition. What I wish to point out most clearly is that there is for each kind of labour a normal wage value, determined by the proportion which the wages in different employments bear, in order that a supply of workers in each may be forthcoming to meet the demand. Also the competition amongst the different classes, or, in other words, supply and demand, constitute the chief forces which tend to maintain wages at this normal value.

The various combinations of employers and employed have attempted to modify the relation between the wages of different

* The British Association 1890 meeting. Presidential address to Section F.

labourers, but whether such combination can effect, under present arrangements, any considerable change of a permanent character, is open to doubt. It seems to me that "corners" in labour, like corners in raw materials, are very likely to defeat their own ends, and that combinations which seek to obtain more than their proper share from the wages and profits fund, are unlikely to meet with other than that temporary success which adjusts their wages again to their normal level. But the present condition of industry is transitory, and only suited to the times. It represents a stage in the growth of industrialism, and as fast as human nature changes to make a better state of things possible, just so fast will a better state be developed. "It is quite possible," as Mr. Spencer says, "to hold that when instead of devouring their captured enemies, men made slaves of them, the change was a step in advance: and to hold that this slavery, though absolutely bad, was relatively good, was the best thing practicable for the time being. It is quite possible, also, to hold that when slavery gave place to a serfdom under which certain personal rights were recognised, the new arrangement, though in the abstract an unequitable one, was more equitable than the old, and constituted as great an amelioration as men's natures then permitted. It is quite possible to hold that when, instead of serfs there came freemen, working for wages, but held as a class in extreme subordination, this modified relation of employers and employed, though bad, was as good a one as could then be established. And so it may be held that at the present time, though the form of industrial government entails serious evils, those evils, much less than the evils of the past times, are as small as the average human nature allows—are not due to any special injustice of the employing class, and can be remedied only as fast as men in general advance."* And there are, here and there, signs of a higher industrial organisation. Co-operation, a system proposed long ago, under which the workers are themselves the capitalists, is making progress. Profit sharing, a system which, after paying fixed wages and fixed earnings of management, allows of another distribution, *pro rata*, from the profits and wages fund, is, in several instances, being adopted. Only slowly, however, are these changes occurring, and several schemes had to be reported by the Labour Association in August as having "been temporarily abandoned, owing to the antagonistic attitude of the several trades unions." A most hopeful feature of this report, however, was that the question as regards the "workers sharing in losses as well as profits, had received a very practical answer from the workers of Messrs. Thomson and Sons, of Huddersfield, whose business was based on industrial partnership lines. Last year it was found impossible to pay any interest on share capital, and the workers resolved to pay interest themselves out of their own wages." † That spirit which freely recognises the claims of all, the sentiment of justice, mutual trust and mutual forbearance, are amongst the factors which will in time produce the industrial reformation.

In the course of this address I have talked of the industrial organism, and the term is not, as might be supposed, a new figure of speech. In its gradual development from a simple to a complex form, in its continued differentiation of functions, in its ever-growing mutual dependence of parts, and in its increasing co-operation of members, industrialism manifests all the changes which take place in the course of organic evolution from the lowest to the highest type. And in the nature of man—the social unit—must be sought the cause of this gradual advancement. As amongst lower animals the increase of numbers and the struggle for subsistence has been the means of developing those special features exhibited by different species, so among men, the redundancy of numbers and the striving of each to gratify his desires have been developing a skill, intelligence, and self-control which will in time lift him from savagery to the highest civilisation. That the present state of society is but transient has been already pointed out. It is the product of past and present, and represents the progress of evolution up to date. It has to be perceived that society is an aggregate of men, that it must therefore manifest in its institutions all the defects possessed by the units of which it is made up. That it is faulty in many particulars is apparent, but that it is the best—nay, that it is the only state possible for the time being, must, at the same time, be admitted. Only as fast as men, the units, advance, and as human nature improves, can a better state of society, the aggregate, arise.

People are loth to believe that institutions can only evolve, are impossible of manufacture. It is sometimes amusing to read the various manifestoes of State socialists, ready with their cut-and-dried schemes to regenerate industrialism, and professing that were their plans adopted, the traits which have characterised humanity through countless ages would forthwith disappear. And yet, perhaps, the published utterances of socialist leaders constitute the best proof that they are unfitted for a better condition of things. Men who talk of confiscating property without the slightest regard for the claims of the owners manifest, by their language, their unfitness for a condition of society which implies a fuller recognition of men's rights. But some are foolish enough to believe that the passing of this or that Act would regenerate humanity, and that the men who show themselves to be guided by the instincts of robbers are those who are to be instrumental in bringing about an industrial millennium. They have history to teach them, but they will not be taught. In olden times the Government imposed endless restrictions on industry, but one by one they have been removed, because found in time to be a mistake and discovered to intensify the evil they pretended to remedy. That the removal of these restrictions has been of immense service to industry most thinking men will admit. Nevertheless, in our day, a school has arisen which demands State interference of such a character that the restrictions of former times pale by comparison.* One can scarcely take up a daily paper which does not contain some attack on a State department for the perfunctory performance of its duties, and yet, notwithstanding this daily accumulating evidence, it is implicitly believed that for all evils to disappear society has merely to be transformed into a huge government office.

That socialism—inasmuch as the term implies complete adaptation to the social state—is the ultimate goal of society has been implied, but that this can be furthered by governments, which exist because of the imperfections of humanity, is doubtful. "Perpetually, governments have thwarted and deranged the growth, but have in no way furthered it; save by partially discharging their proper function and maintaining social order. It is not to the State," quoting Spencer, "that we owe the multitudinous useful inventions from the spade to the telephone; it was not the State which made possible extended navigation by a developed astronomy; it was not the State which made the discoveries in physics, chemistry and the rest which guide modern manufacturers; it was not the State which devised machinery for producing fabrics of every kind, for transferring men and things from place to place, and for ministering in a thousand ways to our comforts. The world-wide transactions conducted in merchants' offices, the rush of traffic filling our streets, the retail distributing system which brings everything within easy reach and delivers the necessaries of daily life at our doors, are not of governmental origin. All these are the results of the spontaneous activities of citizens separate or grouped;"† are, in fact, the results due to competition and to each one endeavouring to satisfy his own individual desires. So much has competition done; but those who have to do with Government departments know well that they are the last places in which enterprise or zeal, or even activity, is to be looked for. It will not do. The first requirement of progress is freedom of action. That everyone shall be at liberty to satisfy his desires in his own way, provided the equal liberty of others is not infringed, is the all-essential condition, for only in the endeavour to obtain their satisfactions have the intelligence and culture of modern times been developed.

I have referred to the improvidence of the working classes, but the influence which bad legislation has had in forming their improvident habits is generally ignored. As a matter of fact, they have been disciplined in improvidence for centuries, the punishment which extravagance should bring having been averted by the operation of the poor laws. Men have been taught that if they lack the foresight or self-denial entailed by preparation for old age, it is the duty of the State to make requisite provision for them, a premium having been thus put upon idleness, improvidence, drunkenness, and licentiousness by taxing the virtuous and independent in order that the vicious might lead easy lives and multiply faster. Our State organised charity is a scandal to civilisation, but State socialism, mark you, is but State charity on a gigantic scale. "It is a fact apparent to every thoughtful man," says a clever writer, "that the larger portion of the misery which constitutes our social question arises from idleness, gluttony, waste, profligacy, betting, and dissipation. Reliance on industry, self-respect, and energy does not enter into the socialistic propaganda. In some vague way the poor man who is a voluptuous prodigal under the present order of things is to become wise and virtuous when property is held in common. But this is loose thinking which deceives no one who can think intelligently. He that is filthy will be filthy still, and he that is unjust will remain unjust in the absence of a moral change within."‡ All legislative attempts to equalise mankind must be futile, and not only futile, but mischievous, as their immediate effect, apart from evils more remote, is to increase the number of undeserving at the expense of the deserving. The human species obeys the laws of life by which all species are governed, and one of the fundamental generalisations of biology is that fertility is determined by environment—that the rate of multiplication is always adapted to the conditions of existence. For every species there is a normal rate of increase, and if from any cause the relation existing between the organism and the environment becomes modified, a corresponding change in fertility results. Other things remaining the same, if the conditions of life are made easier for a species, its rate of propagation increases, and from this universal law there is no escape. If the State by relieving the citizen of responsibilities, voluntarily but imprudently undertaken, makes the conditions of his life less severe, self-reliance is displaced, self-respect is diminished, and self-restraint is discounted. Relieved to an extent of the necessity for individual exertion, the rate of multiplication will rise above the normal, and only fall to it again if from increase of numbers the struggle for existence be raised to its former severity. The mean result of this interference on the part of the State is permanent increase of numbers in a lower grade of life, and permanent diminution in a higher, the struggle for existence being at the same time diminished as regards the former, and increased as regards the latter, temporarily or permanently, as the case may be. Economists are fond of telling us that the "standard of comfort" of the people must be raised if the growth of population is to be checked. In the nature of things this means increased self-denial and a fuller recognition of responsibilities. It means an ideal which can only be realised by individual effort, a something to be by-and-by gained by sacrifice now. The standard of comfort can be raised only by increased

* "The Study of Sociology," p. 253.
† See Report of the Labour Association for 1890.

* See The Radical Programme; Chapman and Hall.
† "The Man v. The State," p. 63.
‡ Mr. Arnold White on "Socialism" in the *Weekly Times and Echo*, September 28th, 1890.

individuation. There is no other way. However implanted, the incentive to rise must act from within, and only by each progressive movement entailing more and more individuation is the energy available for genesis diminished. The gospel of State socialism is mere rubbish. To employ Mr. Arnold White's pithy summary, it is a gospel which equalises "genius and stupidity, industry and indolence, waste and thrift." It constitutes a removal of the forces which have operated from the dawn of civilisation till now to adapt men to the social condition. It comprises an unfitting process under which every deserving member of society gets less than the share he merits, in order that every undeserving member may get more.

From these remarks it must not be thought that I am justifying the present state of industrialism; far from it. My object has been simply to show that it is the best the average human nature of the time will permit of. It is a fact which must be ever kept in mind that human nature cannot be revolutionised by Acts of Parliament, nor can the evils which result from the average defects of humanity be eradicated by State measures. It is equally important to remember that human nature changes slowly, though it is utterly fallacious to assume, as some do, that it changes not at all. It is the function of the Government to protect the citizen from foreign foe and civil aggressor, to enforce justice, to remove hindrances, and permit society, with fullest freedom, to work out its own salvation. If the present were the end, economists might well close their books and admit, with Carlyle, that their science were somewhat dismal. But to those who realise that the present is but a stage in development, and that the process which has already lifted us from savagery to semi-civilisation must continue till the adaptation is complete; to those who believe that in time the traits of a by-gone savagery will disappear, the future of humanity is full of hope. Nor are signs wanting that we are making progress. Notwithstanding the various labour battles being fought around us, I think there is, amongst the more enlightened, evidences of fuller co-operation between the various sections of industry. Both masters and men are becoming a little less selfish, and are getting to trust each other more fully. Aggressiveness on each side is diminishing, and there is distinct indication of growing sympathy between them. As a result, a greater development of profit-sharing arrangements, industrial partnerships and other schemes in which active co-operation is requisite, may be looked for in the near future. In these the hopeful see the beginning of the end.

But by no legislative legerdemain is the final goal to be reached, and it is through the purgatory of competition that we must pass to an industrial heaven. Remember the social state was forced on man by redundancy of numbers. "From the beginning, pressure of population has been the proximate cause of progress. It produced the original diffusion of the race. It compelled men to abandon predatory habits, and take to agriculture. It led to the clearing of the earth's surface. It forced men into the social state, made social organisation inevitable, and has developed the social sentiments. It has stimulated to progressive improvements in production, and to increased skill and intelligence. It is daily thrusting us into closer contacts and more mutually-dependent relationships."* And with each advance in intelligence, with each demand on the increased individuation rendered imperative by the struggle for existence, there goes the inevitable diminution of fertility. "After having caused, as it ultimately must, the due peopling of the globe, and the raising of all its habitable parts to the highest culture; after having brought all processes for the satisfaction of human wants to perfection; after having, at the same time, developed the intellect into complete competency for its work, and the feelings into complete fitness for social life; after having done all this, the pressure of population, as it gradually finishes its work, must gradually bring itself to an end."*

And here, based on history and on science, is foreshadowed a Utopia in the presence of which even dreamers may well stand wonderstruck. From Sir Thomas More to Edward Bellamy, from Fourier to Grant Allen, the thinkers who have been struck with the misery of mankind have each in turn manufactured a system in accordance with their ideas of what ought to be. And, having manufactured a system, they manufactured the human units to suit it. But they altogether ignore the power of the forces which have secured the partial adaptation to work out the adjustment to the end. That the harmony is far from complete is apparent; that man has instincts unfitted for social life is undeniable; but it is none the less sure that the process of adaptation to environment is gradually eradicating those hurtful instincts, and bringing into being emotions corresponding to complete harmony between faculties and surroundings. Nor will work be regarded in any sense a burden when this time arrives. Only pleasure is experienced by the exercise of faculties perfectly adjusted to requirements, and when the adjustment is complete the efforts requisite for existence will constitute but a pleasurable activity. A time must be contemplated when the overflow of capital from rich countries into uncultivated or ill-cultivated regions of the earth must cease, and when for new works of vast magnitude its aid will be no longer required. Due to this lessened demand, the rate of interest will gradually fall, and the inducements to save large sums for one's personal benefit will diminish. The desire to possess great wealth arises because of the power it gives rather than the happiness it secures; but the desire for power, born of aggression, must eventually disappear with the growth of altruistic feelings. If Mr. Ravenstein's figures† are to be trusted, barely two centuries will elapse before the globe is peopled with the six thousand millions it can support, and the condition attained under which the final adjustment of man to his environment must be effected. When this latter is accomplished complete harmony will reign, and so we arrive at a socialism, complete and all-satisfying, achieved by forces older than humanity itself, and worked out by that evolution which clasps the universe in its all-powerful embrace.

* Herbert Spencer's "Principles of Biology," vol. ii., p. 507.

† See Mr. Ravenstein's speech, Conference of Statistical and Geographical Sections, British Association, 1890.

COMPANIES' MEETINGS.

METROPOLITAN ELECTRIC SUPPLY COMPANY.

The third ordinary general meeting of this Company was held at Winchester House, Old Broad-street, E.C., on Friday, the 7th instant, Sir John Pender, K.C.M.G., in the chair.

The **Secretary** (Mr. Cunliffe Owen) having read the notice convening the meeting,

The **Chairman said**: Gentlemen, you have had in your hands a report [published in our last issue] explaining the position of the Company so far, and our reasons for calling this meeting to-day. I presume it is not necessary to read that report. Under the Electric Lighting Act it is provided that companies with statutory powers must present their yearly accounts, made up to the 31st December, to the Board of Trade not later than the 25th March in the year following. You remember that our Company was formed in the autumn of 1888, and we only made up our first year's accounts to the 30th September, 1889, and our general meeting was held to confirm these accounts in December last. The Board of Trade having intimated that they expected us in the future to comply with the statutory requirements, we have found it necessary to alter our financial year, which will therefore end in future on the 31st December. We shall therefore call you together in the spring for the purpose of submitting our accounts, and our meetings will henceforth be held in the beginning instead of the end of the year. I am very glad indeed to meet you to-day, for I am anxious to place before you such information as will enable you to share with the Directors the confidence which they feel with regard to the position and prospects of the Company. I repeat now the policy which I have generally pursued as chairman of other companies—viz., that the more we can strengthen the confidence betwixt Directors and shareholders the more smoothly we proceed and the more satisfactorily the business is conducted. When last I had the pleasure of meeting you I said that we supplied the current for 15,000 lights to 58 customers. We are now supplying current for 40,000 lights to 300 customers. So you will observe, gentlemen, the large increase in lights, and the increasing number of customers. But you can well conceive what an enormous number of customers we have yet left to supply. That is one of the great features of this Company's prospects at the present moment that we have such a wide field before us, and I think that I will be able to satisfy you before I sit down that we are likely to occupy that wide field with considerable benefit to all concerned. I may state that this number (of lights and customers) is largely in excess of that supplied by any other company in the United Kingdom, and that it is equal to over one-third of the total lights supplied in London by public companies. I am informed by our Manager that the whole of the contracts for a further 10,000 lights are taken up, and that there are many more applicants who are negotiating with us for the supply. It is our experience that the number of applicants grows steadily. I have in my hands a table showing the monthly increase of our lighting during the present year, which will give you some idea of the steady growth of the business. I can also read to you a few of the testimonials we have received expressing entire satisfaction with the supply. Now that is another important point. I daresay you have heard a great many complaints about the work of the electric light supply companies. We have had nothing but complimentary letters from our customers. The Chairman then read testimonials from Mr. Augustus Harris, Drury-lane Theatre, "Electric supply in every way satisfactory"; Mr. Geo. Edwards, Gaiety Theatre, "Light extremely satisfactory"; Mr. Kennedy, Exeter Hall, "Installation a complete success"; Mr. Compton, Garrick Theatre, "Lighting in every way satisfactory"; Messrs. Hampton and Sons, "Lighting most satisfactory, the whole 640 lamps give a good and steady light"; Mr. Hare, speaking as an actor, "When I leave the theatre at night I feel quite a different man from what I used to do when we had gas." I have not given you private testimonials, I have given you testimonials from theatres, where it is so important that the light should not only be steady, but brilliant; and I think this evidence of what we are doing is very striking evidence of what we may expect in the future. I am going to show you now the state of our lights and how they are growing. We begin with March, when the spring days are longer and less light is taken; ending in November, when winter, the time of greatest demand, is just beginning. On 1st March we had 16,000 lights; on 1st April, 19,000 lights; on 1st May, 21,000 lights; on 1st June, 22,000 lights; on 1st July, 23,000 lights; on 1st August, 30,000 lights; on 1st September, 33,000 lights; on 1st October, 36,000 lights; on 1st November, 40,000 lights. You will observe that we have passed through the summer with a very fair average increase. We have been rising to a point which is very considerable, and before the end of the year I expect to see at least 10,000 lights added. That, I am sure, you will agree with me, is satisfactory as to the progress of the Company. A glance at the map which we have had prepared

(it hung on the wall behind the speaker) will show you the magnitude of our operations. You will notice the supply stations, Whitehall, Sardinia-street, Rathbone-place, and Manchester-square, together with the vast system of underground mains that have been carried out. Upwards of 40 miles of mains have been already laid, and we roughly estimate that to complete our system at least double this quantity will be required. That will give you an idea of the work that has had to be done, and the time that is required to do it. The following statistics on the subject of our areas are of interest, as showing their magnitude and importance. The average acreage is 3,105, houses 45,451, with a ratable value of £4,500,000. The report states that we have obtained powers over Paddington. We have obtained an advantageous site on the canal bank, and are about to begin works. While this station is being constructed we will be able to supply from Manchester-square such lights as we can lay mains for in the Paddington district until the whole system there is completed. I may here observe that we have no intention of applying for further districts at the present time. We do not consider that we will be justified in incurring further responsibility and liability. We are satisfied that our present areas are amply sufficient both in size and importance to take up all our energies at the present moment. Our capital at the present time is £500,000. When I was examined before the committee appointed to enquire into the electric lighting of London, I said I would not be satisfied until our capital became at least £2,000,000 sterling. I hold the same opinion to-day. With two years of experience of work before us, I believe that it will be so successful—so remunerative—that we will gradually extend our system until we have got at least a couple of millions of money invested in it. I will now describe to you the present condition of our supply stations. Whitehall station has caused us a certain amount of disappointment, owing to the fact that the large block of buildings called Whitehall-court, which it was originally intended to light, has not been taken up as rapidly as those who built the chambers expected it would be; consequently there has been some delay in the Whitehall station being as productive as we at one time expected it would be immediately. But I am glad to say that those chambers are now beginning to attract considerable attention, and probably before I have the pleasure of meeting you again I may be able to report that a considerable number of those chambers are being lighted by the Whitehall system. I may mention to you that in the Whitehall system 710 h.p. is employed, that it supplies 5,000 lights, and is capable of extension to 8,000 lights. The next station is Sardinia-street. We have every reason to be satisfied with the working of the very important station here. I informed you at our last meeting that we had given an order for double the plant. This contract has now been carried out, the machinery is in working order, and we are ready to cope with any demand that may arise. We have at this moment 19,500 lights running, and we have here a plant equal to supplying 50,000 lights. The demand is increasing, and now that we are in winter it is increasing at a rapid rate, so much so that until we have our mains complete we are not canvassing for work. We are only taking up work brought to us. The next station is Rathbone-place. I have already informed you of the circumstances that led to the purchase of this station. The new machinery is fast approaching completion, and, indeed, it would have been finished before now but for difficulties which have been overcome. If a man has a house alongside an electric installation, his belief is that he ought to bleed the company to some extent, and we have had injunctions without number. All these injunctions are overcome in Rathbone-place, and the other day the proprietor of the place died, and his property was brought to the hammer. I went to that sale, after consulting with my co-directors, and we bought it. Purchasing that site frees us from all injunctions or trouble in the future; in the second place, it gives us something like 8, or 9, or 10 per cent. We will be able to get money for a great deal less, so that at the end of 21 years, in which, according to the existing agreement, we would have had to pay double our rent, we shall, at the end of 21 years, be able to stand without any rent at all—in other words, we shall have our station practically free at the end of that time. That must be satisfactory. Rathbone-place is a most central station, and every light is likely to be required. The horse-power is 1,200, and the supply, when finished, will be 21,000. The next station is Manchester-square. To this we attach the very greatest importance. It is situated in the wealthy parish of Marylebone. At the last meeting I informed you we had made advantageous terms with the London Electric Supply Company, by which we took over the existing network of mains in the Marylebone district. We were thus able to supply as soon as the machinery was ready to run. Our machinery has only been working four months, and we are enabled to supply 11,000 lights. The Directors have always laid very great stress upon communication by trunk mains between one station and another. By this means we shall always be able to cope with a sudden demand, and should any accident arise the load of one station could be at once transferred to another. That, when this Company was originated, was one of the great points, that we were not to speculate, we were going to allow other people to experiment, and we would take the results of those experiments; but we would so arrange our stations that if anything occurred to one of them the others would be brought in contact with it, so that at the present moment, while we stand with all these different installations, we can unite them together and make one powerful combination at any moment. This is a very great and important feature.

The laying of our mains has taken considerable time to effect, and I am sure that you will realise that we have had to encounter difficulties in our works. Anyone walking about the streets will see the interruption to traffic that is caused by the laying of these mains. Shopkeepers complain, everyone complains, and it is not a pleasant task to keep things quite smooth. Well, we have got on fair terms with people, and we are pursuing our work steadily and successfully. The whole of these works are being executed by our own men under the superintendence of our own staff, and this is a more economical method than employing contractors. These works have brought us into frequent contact with local authorities and the County Council, and I will take this opportunity of expressing our appreciation of the kindness and courtesy shown to us by the officials of these bodies.

Coming to our financial position, I would remind you that under the circumstances we have called you together, we have no audited statement to submit. We have, however, gone carefully into the matter, and it will be satisfactory to you to learn that in spite of the small amount of our revenue at the close of last year and commencement of this, we have every reason to believe that we have more than paid our way—that we have made a profit in the short time that we have been earning—and that profit has been made upon something like 30,000 lights. We are very pleased to make this statement for the following reason, which we are anxious you should carefully bear in mind: our working expenses in the past and present are, with one exception, the same as they will be when we are supplying our full supply of 114,000 lights. That is a very important thing. The staff of to-day has to deal with a production of 40,000 lights. The same staff will be quite equal to cope with an output of 114,000 lights; and, as I said to you, we have made a small profit upon the out-turn of 40,000 lights. It does not want much imagination to realise that if we can deal with 114,000 lights with the same staff with only an increased consumption of coal, we have a very good business before us. We calculate that we shall supply, after calculating the current expenses for staff, the cost of coal and working the machinery, we shall be able to supply for about 3½d. per unit—that is a most satisfactory point. As you know, we get 7½d.; there is a very considerable margin between 3½d. and that. I have to explain, and you may naturally ask, Why should we spend so much at the present moment upon staff? This is a new system. We have had to train almost every man for this particular system. We have had to keep up a much larger staff with a view to the extension that is likely to take place in the demand, and we felt that the best and safest method was to educate our own men for the purpose. Therefore, as we grow our trade will grow, and that staff will be absorbed in the extension. With the present large growth of business and with an assurance of a continuous and steady increase, we believe that we are perfectly justified in stating that we look forward to a satisfactory dividend being earned in the next year. I have heard people say that a dividend should be earned this year. The Company has only been founded two years, and has been in possession of parliamentary powers little more than one year. During this time works have had to be executed, and already we are able to announce that with an average output during the present year of, say, 25,000 lights, and with our working expenses almost as heavy as they ever will be, we have run at a small profit. Our stations have sufficient h.p. available to supply, when fully taken up, 114,000 lights, and when I state that 30,000 lights gives us a small profit, you can calculate the difference between 30,000 and 114,000, with only the additional cost of coal to be deducted, and the very considerable income that may be expected with this large addition to the number of lights. I don't like to promise or prophesy, but I have said that this Company must grow to be a very large one, and I state it now with a great deal more confidence than I said it before, and Sir George Elliott, though not present to-day, owing to ill-health, concurs in the views expressed to you. When I look back to the days in which I have been connected with electricity, I think we did a little bit of prophecy then, but our prophecies were realised, and I personally believe the above statement will be realised in the future of the Metropolitan Supply Company. I beg to thank you for being present here to-day, and move that the report of the Directors be and is hereby received and adopted. If anyone has any questions to put I shall be happy to answer them.

Mr. Fowler: I have pleasure in seconding that.

A **Shareholder** asked whether he was to understand that 30,000 lights and £30,000 were practically the same thing?

The **Chairman**: Not necessarily. We are selling our electricity by meter.

The **Shareholder**: I want to form an idea of what 100,000 lights mean in pounds sterling.

The **Chairman**: I am not going to prophesy; but if you ask my private opinion, I think you are very safe in taking it at 10s. per light.

A **Director**: More than that.

Another **Shareholder**: Will you kindly inform us what is the present revenue of the Company?

The **Chairman**: I have read to you how the thing has grown during the last few months. I should think, at the present time, I would estimate the income of the Company for the current quarter at £10,000.

Another **Shareholder** was pleased to know they had so much skill on their management, and wished to ask whether, like their neighbours, they were making any arrangement for supplying motive power as well as light?

The **Chairman**: The demand for light, which is our primary object, is such at the present time that we will not—we have no time to—turn our attention to the supply of motive power.

Mr. Giles asked as to their Paddington district—did what had been said mean that other companies would have it? And, as to the increase of capital to £2,000,000—did that mean that more shares were to be issued?

The **Chairman**: What I said was this—that our capital was £500,000. We shall not put down new installations until we have altogether satisfied you that the installations that are working are paying us a handsome profit. The moment that we prove the system to be thoroughly paying and successful—mechanically, electrically, and financially—then I will call upon you to add another half a million. It is not for me to criticise what other companies are doing. I stated when I first addressed you that we are not a speculative Company. I think I may say that we have managed our capital perhaps more prudently than other people, and get more for our money than others. As to the Waterloo Wharf work. There is always a thorn in the flesh. We have tried very hard, and I have paid a great compliment to the County Council. I must say that they were not right at one time, because I had to address the Chairman personally on the subject, but they are all right now. We are utilising that station for a storehouse. It is on the Embankment, and it is very useful. We have in existence now the plant that we intended to put down there, and are keeping it unemployed; but there is a wide field in that district which we shall not enter upon until we satisfy you that the other fields are productive. You cannot get a dividend out of nothing. When we were spending money to create all these installations which are now beginning to bear fruit, it was not possible for us to pay you a dividend. Our installations are nearly completed, and we are earning money, and our lights are being taken up very rapidly, therefore, when I meet you again I think I will be able to announce to you something satisfactory in the way of a dividend.

The resolution adopting the report was then put and carried unanimously.

Mr. Giles next proposed the re-election of Sir James Anderson, Sir James S. Balfour, M.P., and Sir George Elliott, Bart., M.P., as Directors, which was carried unanimously.

Messrs. Deloitte, Deever, Griffiths, and Co., were re-elected Auditors.

The usual vote of thanks to the Chairman and Directors brought the meeting to a close.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.

The twenty-seventh ordinary general meeting of the proprietors of this Company was held on Wednesday at Winchester House, Old Broad-street; Mr. C. W. Sarle in the chair.

In moving the adoption of the report, the **Chairman** said that the account was more satisfactory than any other which it had been in their power to present to the shareholders. It was not, however, a good account at best; and as long as the condition of the field in which they worked remained as it was now, he did not see the possibility of their position ever being brilliant. But there were still features which could not but be regarded as satisfactory. The traffic receipts were slightly larger than they had ever had before, while the working expenses outside the repairs had been rather below the average, and the result was that the net outcome was larger than they had ever previously shown. They appeared to be within measurable distance of getting rid of the incubus which had weighed upon them for so long a period in the shape of arrears of dividend on preference shares. They owed now £1. 8s. 6d. per share on the second preferences, the total being £6,653, whereas in 1884 the amount owing to preference shareholders was £65,000. He thought under the circumstances they would admit that good progress had been made considering the poor traffic they enjoyed. With regard to the Barbadoes and Demerara cables, he said that they had settled the terms upon which a new cable should be laid to Barbadoes, and the cable had been laid. They were now in process of negotiation for a duplicate cable to connect Demerara with the system at Trinidad. Those works, however, would not bring additional revenue, because they were only duplications; but they would save them from loss and inconvenience consequent upon interruption in the future. The traffic accounts for the current half-year were good, and he had reason to hope that better things were coming on for them as well as for the West Indies. They must not expect, however, to jump into dividends, as the West Indies formed an extremely poor field for oceanic telegraphy.

Mr. Ford seconded the motion, which was adopted after a brief discussion, and the meeting closed with a vote of thanks to the Chairman and Directors.

WESTERN AND BRAZILIAN SUBMARINE TELEGRAPH COMPANY.

The twentieth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on Thursday morning, Mr. W. S. Andrews in the chair.

The report with accounts to June 30 last was taken as read. In it the Directors stated that the "total earnings amount to £89,846. 13s. 9d., as against £86,555. 17s. 10d., an increase of £3,290. 15s. 11d. compared with the half-year to June 30, 1889. The working expenses amount to £40,509. 13s. 3d., as against £39,104. 15s. 5d., an increase of £1,404. 17s. 10d. This increase is attributable to a larger sum having been written off the steamers on account of depreciation (£1,031), to the rise in the price of coal, to the opening of a new station, and to the larger volume of traffic. Including the amount brought forward from 1889 (£3,248. 16s. 6d.), and the dividend received upon the shares held in the Platino Company to June 30, the balance to the credit of the revenue account is £59,970. 17s., from which has to be deducted £13,220 for debenture interest, leaving £46,750. 17s., of which £7,500 has been placed to the renewal fund, and £5,880 to the debenture redemption fund. This leaves £33,370. 17s. The Directors recommend the payment of a dividend of 6s. per share, free of income tax, on the ordinary shares for the half-year, being at the rate of £4 per cent. per annum, carrying forward £5,751. 7s. At the corresponding period last year the dividend was at the same rate. Since the last half-year's report 30 Platino shares have been exchanged for 18 shares of this Company. The dividend warrants will be posted on the 14th November. An agreement for the absorption of the Montevidean and Brazilian Telegraph Company, Limited, will be submitted for the approval of the meeting. The undertakings are so closely allied that it is most desirable they should be brought under common control, and it is now proposed to purchase the above company by an issue of 5,300 ordinary shares of £15 each in the Western and Brazilian Telegraph Company, Limited, ranking for dividend earned after 1st January next. The agreement at present subsisting provides for the payment to that company of a percentage of the gross receipts of the Western and Brazilian Telegraph Company, Limited. This payment, forming a portion of the amount paid to the London Platino-Brazilian Telegraph Company, Limited, is a charge coming between the A and B debenture issue of the Western and Brazilian Telegraph Company, Limited. Consequent upon the arrangement now proposed, the proportion of this charge, hitherto paid to the Montevidean Company, will disappear. The Directors have the pleasure to state that after long and difficult negotiation the Government of Brazil have authorised the Company to lay alternativeecables. The thanks of the Company are due to the Government of the United States of Brazil for this decision. Steps will now be taken to lay the lines immediately necessary."

Having given some financial details, which he said showed quite an ordinary state of things, the **Chairman** remarked that this did not quite hold good with respect to what he might call the political aspect of affairs. When they met 12 months ago they were in rather a parlous condition, the Brazilian Government having absolutely refused to permit them to lay loop cables; in other respects, too, the position out in Brazil was extremely unsatisfactory, to give a mild description of it. Immediately after their meeting—in fact, within 24 hours—there was a change of Government in Brazil, and instead of having to deal with an Empire they had to treat with a Republic, and their experience of a Republican Government was more satisfactory. They (the Directors) did all they could to obtain the support of the British Government, and Lord Salisbury met them in a very fair spirit, and they obtained a moral support which had greatly benefited them, and which, no doubt, was appreciated by the Brazilian Government. They brought forward every point they could; their representative in Brazil was exceedingly active and able, and had conducted the negotiations in a way which had earned the satisfaction of the Board. They succeeded in convincing the Brazilian Government, who had seen that any step of that kind must, as it had already done, redound to their credit in the financial centres of the world, and that it must also benefit the commerce of the country. The loop cables were finally authorised to be laid. In connection with the conduct of the negotiations and the activity, prudence, and discretion exercised by the Board in conducting them, he would specially mention the valuable services of Major Wood, managing director, and their worthy secretary, Mr. R. M. Cunningham. They were not to suppose that the laying of these cables would produce increased revenue; that was not the object of laying them. The object was to enable them to fulfil their concessional obligations more effectually, and at the same time to safeguard their line against interruption, the benefit of that being that they did not sustain loss of revenue by interruptions, and to that extent there was a financial gain. The laying of the cables would also obviate their having under their agreement with the Brazilian Company to forfeit a sum of £5,000 a year. Having explained the nature of the agreement to purchase the Montevidean Telegraphs, dealt with in the report, the **Chairman** moved the adoption of the report and accounts, which was seconded by **Mr. Earle**, and carried unanimously.

NEW COMPANIES REGISTERED.

London Carbons Manufacturing Company, Limited.—Registered by H. Grain, Bedford-row-chambers, with a capital of £2,000 in £1 shares. Object: to acquire licenses to manufacture carbons. Most of the articles of Table A apply.

Electrical Supplies and Fittings Company, Limited.—Registered by Wilson, Bristows, and Carpmael, 1, Copthall-buildings, E.C., with a capital of £20,000 in £5 shares. Object: to carry on the business of electricians and mechanical engineers. The first subscribers are:

	Shares.
G. L. A. Rooke, 14, Keppel-street, W.C.	1
J. A. Roxburgh, 77, Queen's-road, Finsbury Park	1
J. Whitehead, Heycott, Crouch End	1
T. B. Arundel, 1, Devonshire-street, Portland-place	1
W. L. Madgen, 3, Princes-mansions, Victoria-street, S.W.	1
N. G. Bingham, C.E., 29, Notting-hill-terrace	1
G. S. Butler, 15, Peak-hill, Sydenham	1

There shall not be less than three nor more than nine Directors. The first to be appointed by the subscribers to the memorandum of association. Qualification: £200. Remuneration: £500, and

one-tenth of net profits after 8 per cent. dividend, with the proviso that the whole remuneration of the Board shall not exceed £1,000, the same to be divisible.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the past week amounted to £5,112.

The Anglo-American Telegraph Company have opened an office for the reception and delivery of telegrams at No. 2, Northumberland-avenue, Charing Cross.

Western and Brazilian Telegraph Company.—The receipts for the week ended November 7, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,979.

Commercial Cable Company.—This Company has opened a branch office at 4, Charing-cross, S.W. (opposite the Grand Hotel), and the West-end of London is now in direct communication with the United States and Canada, etc.

Swan United Electric Light Company.—The accounts for the year ending September 30th, 1890, have been before the Directors, and, subject to audit, they have resolved to recommend the shareholders to declare a dividend at the rate of 10 per cent. per annum at the meeting which is to be held on the 25th inst.

Notice of Removal.—Messrs. Davey, Paxman, and Co. inform us that they have removed their London offices to larger and more convenient premises situated at 78, Queen Victoria-street, E.C. Telegrams intended for the London office will be addressed "Paxman, London," and their telephone number will be 1,697.

Montevidean and Brazilian Telegraph Company.—An extraordinary general meeting of this Company will be held at Langthorn House, Copthall-avenue, E.C., on the 25th inst., at 11.30 a.m., when resolutions will be proposed for the voluntary winding up of the Company, the appointment of Mr. George Fraser as liquidator, and the approval of an agreement to sell the Company's undertaking to the Western and Brazilian Telegraph Company.

Personal.—Messrs. J. D. F. Andrews and Co. have purchased the goodwill and assets of the firm of Messrs. White, Romanze, and Co., of Kingsbury-road, Dalston, and 3 and 4, Great Winchester-street, E.C., who have been carrying on a considerable business in the manufacture of arc lamps, switches, etc., and also telephones, type printing instruments, and electric bells, besides many important electric light contracts. Messrs. Andrews and Co. intend continuing all the manufactures hitherto carried on by the late firm, but they are about to remove the machinery from Dalston at an early date to more commodious premises. Mr. F. White, of the above firm, who is well known in connection with electric light and telephone work, has assumed the position of manager with Messrs. Andrews and Co.

PROVISIONAL PATENTS, 1890.

NOVEMBER 3.

17580. **Improvements in the decorative arrangement of electric lights.** John Macintosh Mackay Munro, 154, St. Vincent-street, Glasgow.

17589. **Improved means for lighting street gas lamps by electric spark.** Charles Barnett, Latimer-road, Godalming.

17600. **An electrical switch for opening and closing of circuits, switching on currents, and so forth.** Albert Charles Lainchbury, 12, Folkestone-road, Upper Edmonton.

17611. **Improved electrical push-button for signalling circuits.** Charles Denton Abel, 28, Southampton-buildings, London. (Heinrich Messing, Germany.)

17631. **Improvements in or relating to electric accumulators.** Peter Lauber, 323, High Holborn, London.

17635. **Improvements in electrodes and isolators or divisions for batteries.** Paul Schoop, 46, Lincoln's-inn-fields, London.

NOVEMBER 4.

17690. **Method of and apparatus for obtaining electricity by hydraulic power.** Charles Adams Randall, 3, Woodstock-road, Bedford Park, London.

17711. **Improvements in means for the distribution of electricity.** Henry Edmunds, 47, Lincoln's-inn-fields, London.

17728. **Improvements in electric railways.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

17735. **Improvements in automatic regulators for dynamos and motors.** Fremont John Cleaver and George Fassold, 53, Chancery-lane, London. (Complete specification.)

NOVEMBER 6.

17829. **Improvement in incandescent lamp-holders or suspenders.** James Edward Charnock, New Bridge-street, Manchester. (Clement Charnock, Russia.)

17851. **Improvements in electric thermostats for ships' bunkers, refrigerating-rooms, and other purposes.** Henry Binko, 34, Leadenhall-street, London.

17861. **Improvements in the manufacture of electrical conductors and electrodes, and for connecting them; and for other analogous purposes.** Julius Marx, 47, Lincoln's-inn-fields, London.

17863. **Improvements in portable electric lamps.** Mads Peter Hardt, 433, Strand, London.

17870. **An improved make and brake action adapted to the purpose of an electric switch.** William McGeoch, Temple-chambers, London.

NOVEMBER 7.

17899. **An improved self-locking electric switch.** William Lownds, Elliott Emanuel, and Joseph Wood, of the firm of A. Emanuel and Sons, Limited, Fairlawn Park, Chiswick, London.

17905. **An induction transformer coil, and methods of using the same for telephone call bells and other purposes.** Carl Thomas Blanch Brain, Helsby, near Warrington.

17912. **An electricity meter.** James Thomson Bottomley, 154, St. Vincent-street, Glasgow.

17919. **Improvements in electric energy meters.** Roger Joseph Francis Mostyn, 30, Maitland-park-road, Haverstock Hill, London.

17929. **Improvements in or connected with armatures for dynamo-electric machines.** Bronislas Rejchman, Norfolk House, Norfolk-street, London.

17937. **Improvements in and relating to electric lamps or lighting apparatus.** Frédéric Victor Maquaire, 45, Southampton-buildings, London.

17940. **Improvements in arc lamps.** Siemens Bros. and Co., Limited, 28, Southampton-buildings, London. (Siemens and Halske, Germany.)

17941. **Improved means for charging accumulator batteries on electric circuits supplied by current generators.** Siemens Bros. and Co., Limited, 28, Southampton-buildings, London. (Siemens and Halske, Germany.)

17951. **Improvements in electric switches.** Henry Harris Lake, 45, Southampton-buildings, London. (Frederick Clarence Jenkins, Germany.)

17954. **Improvements in electrical accumulators or storage batteries.** Henri Louis Maugras, 323, High Holborn, London.

NOVEMBER 8.

17976 **Improvements in means for firing ordnance charges by electricity.** George Quick, Glenbank, Carlton-road, Bournemouth.

17987. **Improvements in electro-medical appliances.** William Randolph Varney, 5, Magdala-buildings, Weston-super-Mare.

18034. **An improved electric switch.** George Frederick Redfern, 4, South-street, Finsbury, London. (Adolf Schirner.) (Complete specification.)

SPECIFICATIONS PUBLISHED.

1889.

13089. **Field telegraph.** Glen. 8d.

16237. **Electrical mains.** De Ferranti. 8d.

18350. **Dynamo-electric machines.** Davies. 8d.

18755. **Secondary batteries.** Reckenzaun. 6d.

19011. **Dynamo-electric machines.** Hopkinson. 8d.

19190. **Induction coils, etc.** Lovell and Lloyd. 6d.

19554. **Alternating-current generators.** Von Dolivo-Dobrowolsky and others. 11d.

19555. **Electrical induction transformers.** Von Dolivo-Dobrowolsky and others. 8d.

1890.

3094. **Electric lamps.** The Mining and General Electric Lamp Company, Limited, and others. 8d.

11657. **Electric dental pluggers.** Gibbs. 8d.

12777. **Electric conductors.** Gould and Schalk. 6d.

14603. **Electric signalling.** Lake (the Hall Signal Company). 8d.

14604. **Heating metals, etc., by electricity.** Dewey. 8d.

19892. **Welding metal by electricity.** Fowler. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2½
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	8

NOTES.

Brugg, a small Swiss town, is to be lighted electrically.

Drury Lane Theatre.—Drury Lane Theatre is being fitted with electric light.

Ryde Pier.—A 20-h.p. Stockport gas engine is being erected for electric lighting at Ryde Pier.

Church Lighting.—Electric lights have been introduced into St. John's Church, Kennington.

Daventry will not consent to Messrs. Latimer Clark, Muirhead, and Co.'s applying for an order.

America.—It is stated that £23,752,000 represents the capital invested in electric lighting in the States.

Segovia has an installation of 600 incandescents. The motor is a turbine. Senor H. Bentabol was the engineer.

Personal.—Lord Rayleigh has been appointed an honorary member of the Bavarian Royal Academy of Science.

Houses of Parliament.—Several additional rooms have been wired during the recess, and will be lighted in the coming session.

New Switches. — We understand that the Acme Works are bringing out a new and improved switch for secondary main circuits.

The Lincoln County Council are charging the National Telephone Company 5s. per mile for the right to erect and maintain posts.

Regent-street Mains. — Huge Siemens insulated mains are being laid in Regent-street as secondary mains for the London Electric Supply Corporation.

An Exhibition, which will include an electrical section, is to be opened at Bordeaux on the 1st May next. The offices are at 7, Allée de Tourny, in that city.

Cantor Lectures.—On Monday next, at 8 p.m., Prof. Vivian B. Lewes will give the first of the Cantor lectures on "Gaseous Illuminants," at the Society of Arts.

Prof. Ewing, of University College, Dundee, has been elected to the chair of mechanism and applied mechanics at Cambridge, vacant by the resignation of Mr. Stuart.

British Columbia.—The contract for building a central station at New Westminster, which was let to Mr. E. Burns some month or two ago, is to be completed by the 29th instant.

Buenos Ayres.—Messrs. Verity and Sons have lately completed an installation of 700 lights in Buenos Ayres—begun some time ago, but stopped on account of the Argentine revolution.

Personal.—M. Marcel Deprez, the well-known electrical engineer, has been appointed to the chair of electricity at the Paris Conservatoire des Arts et Metiers; MM. Hospitalier and Mercadier were also candidates.

Bournemouth.—At the last meeting of the Improvement Commissioners the application of the National Electric Supply Company, for consent to a provisional order, was referred to the newly-elected Council.

The Telephone in Hants.—The Hants County Council have contracted with the Western Counties and South Wales Telephone Company for inter-telephonic communication between police stations.

Falkirk (Scotland).—The Lighting Committee have decided to invite tenders for supplying electric light in the principal thoroughfares of the town. Gas is so dear and so nasty that Falkirk desires no more of it.

Royal Society.—Yesterday afternoon (Thursday) Prof. J. V. Jones was to read a paper on "The Specific Resistance of Mercury in Absolute Measure," and Dr. Hopkinson, F.R.S., one on "Magnetism and Recalescence."

Gravesend.—The compulsory area here is limited to New-road, King-street, Milton-road, as far east as Holy Trinity Church, High-street, Windmill-street, as far south as and including Woodville-gardens, and Railway-place.

Australian Cables.—The Hon. John Gavan Duffy, Postmaster-General in the new Cabinet of Victoria, has expressed himself in favour of the cable guarantee, notwithstanding the refusal of Queensland and New Zealand to bear a share.

Madrid.—The two stations here, one belonging to the House-to-House and the other to a German company, have in hand orders for about 17,000 lamps. The price is over 1s. 2d. per unit. The price for gas in Madrid is 8s. per 1,000 cubic feet.

Coventry has determined to limit its compulsory area under the Electric Lighting Acts to Broadgate, Smithford-street, Fleet-street, High-street, Earl-street, Jordan-well, Hertford-street, Cross-cheaping, Burges, Hay-lane, Priory-row, and Bayley-lane.

Leamington.—The Corporation advertisement, giving notice of their intention to apply for an order, is out, and from it we gather that the compulsory area will include High-street, Bath-street, Victoria-terrace, The Parade, Regent-street, and Warwick-street.

Award.—On Wednesday evening, after his address to the Society of Arts, the President (Sir R. Webster) presented the silver medal of the society (among others) to Dr. J. A. Fleming, for his paper on "Prof. Elihu Thomson's Electromagnetic Induction Experiments."

Dover.—The cost of obtaining orders was illustrated at the last meeting of the Dover Town Council by a councillor calling attention to the fact that the expenses up to date under this head had been £400. No less than £102. 10s. of this amount was for printing.

Book Received.—"Anleitung zum Bau Elektrischer Haustelegraphen, telephon, und blitzableiter-Anlagen," or, "A Handbook on the Construction and Maintenance of Domestic Telegraphy, Telephones, and Lightning Conductors," published by Herren Mix and Genest, of Berlin.

London Central Railway.—The promoters of this line are taking heart of grace, and intend to apply to Parliament again next session for powers to construct an electric railway from the terminus of the City and South London Railway in King William-street to Queen's-road, Bayswater.

New Paper.—We have received the first copy of a new venture in electrical journalism, entitled *Electricity*. It is edited by Dr. Julius Maier and published by Messrs. Swan, Sonnenschein, and Co. The chief point about this little weekly is that it can be purchased with the humble penny.

The Telephone at Leamington.—The United Telephone Company are desirous of beginning operations here, and promise as soon as 12 subscribers are found to open an exchange. The subscriptions are to be £10 per

annum for first connection, and £7. 10s. for every subsequent one.

Barrow.—The Corporation, who have an order, have issued invitations to all business or private persons who would be disposed to take the electric light for their homes or shops to send in their names, so that they may consider the advisability or otherwise of supplying the borough with this light.

Electric Trades' Section.—The chairman and the two vice-chairmen—Mr. Crompton, Mr. Garcke, and Major Flood-Page—have agreed to act as an executive committee, instead of appointing a secretary in place of Mr. Trotter resigned, and the London Chamber of Commerce will allow the use of a clerk.

Long-Distance Telephony.—The National Telephone Company, Limited, announce that the trunk line between the London, Manchester, Liverpool, and Birmingham exchanges is now open to the public. The charge for three minutes' conversation is 3s. to Manchester and Liverpool, and 1s. 6d. to Birmingham.

London Electric Supply Corporation.—A fire occurred at this company's temporary premises, Blomfield place, New Bond-street, W., on Saturday last, owing to the formation of an arc and want of presence of mind of an employé combined. We have alluded to the matter in detail in our leader this week.

Windsor.—Mr. Wm. Beach, treasurer of the borough of Windsor, and auditor of the Windsor Gas Company, has been appointed auditor of the Windsor and Eton Electric Light Company. The Urban Sanitary Authority have appointed an Electric Light Committee, consisting of the whole of the members of that body.

More High Voltage.—Mr. Gisbert Kapp has been testing with 14,000 volts on the Brooks's liquid insulation system at Messrs. Johnson and Phillips's works at Charlton, Kent. The mineral oil of the Brooks's system would thus seem to be aiming for a rivalry to the celebrated paper and black wax insulation of the Ferranti system for the transmission of extremely high voltages.

Institution of Electrical Engineers.—At the meeting on the 27th instant, there will be an adjourned discussion on the following papers—"The Efficiency of Secondary Cells," and "On the Chemistry of Secondary Cells," by Prof. W. E. Ayrton, F.R.S., vice-president, C. G. Lamb, B.Sc., and E. W. Smith, associates.

Cardiff.—The compulsory area at Cardiff includes the following streets: Queen-street, Duke-street, Castle-street, High-street, Saint Mary-street, Saint John-street, Working-street, The Hayes, Trinity-street, Wharton-street, Church-street, Caroline-street, Custom House-street, and Bute-street from Custom House-street to The Hayes.

O.S.A.—A cinderella dance will be held at the Westminster Town Hall on Friday, December 12th. Tickets (3s. 6d. each) may be obtained from Miss Walter, 38, Woodbury-grove, Finsbury Park, N.; Dr. W. E. Sumpner, Central Institution, South Kensington; Mr. H. B. Bourne, 41, Priory-road, Bedford Park, W.; or any other of the members of the committee; or from the hon. sec.

Harrogate.—The Town Council have resolved to light the whole of the borough with the electric light, and that action be taken on the matter within the next two years. The Mayor (Mr. Sampson Fox) was averse to the proposal; but on its being carried by the Council, he expressed his willingness to assist in every way to carry it out with success.

Stroud (Gloucester).—A meeting promoted by Messrs. V. A. Lawson and E. N. Witchell, of Stroud, was held at the Subscription-rooms last week to consider a proposal to light the town by means of electricity. The meeting passed a resolution approving of the scheme, and recommended the appointment of a committee.

New Tramway.—At the last meeting of the Blackpool Town Council, a letter was read from Mr. Charles Chadwell, C.E., enquiring if the Corporation would give their assent to the construction of a tramway from Lytham and St. Annes to and into the borough, to be worked by storage cars. The Council declined to move without further particulars.

High Voltage Transmission.—The Oerlikon Company are erecting a long-distance transmission of power on the Kapp system for the Frankfort Exhibition at 10,000 volts. The current will be generated at ordinary alternating current pressure about 2,000 volts, and transformed up to the 10,000 volts, transmitted along bare overhead wires carried on oil insulators, and again reduced at the exhibition end.

Ship Lighting.—The Naval Construction and Armaments Company, of Barrow-in-Furness, have secured a subsidy from the Dominion Government for the new fast Atlantic liners which they are to build. These steamers are to have a speed of not less than 20 knots, and will be lighted electrically. The contract for the lighting has not yet been given out.

Blackpool Tramway.—The report of the directors of the Blackpool Tramway Company, which will be found elsewhere, is satisfactory, though there has been a slight falling off in receipts as compared with the previous year. This, however, is accounted for by the fact that the number of miles run by the cars is 2,000 less than last year. The directors recommend a dividend of 7½ per cent.

The Brush Company's Show Room.—So many enquiries are constantly addressed to the Brush Company for particulars as to the wiring of houses and the artistic fittings appertaining thereto, difficult of satisfactory solution at their Lambeth premises, that they have determined to start a West end showroom, which will be opened almost immediately at Langham House, Regent-street.

Swan United Company.—The twenty-fifth ordinary general meeting of this company is to be held at Cannon-street Hotel on Tuesday next, at 12 o'clock. The report is published in this issue, and it will be seen that the directors recommend a dividend for the year of 10 per cent. The patent suits in Germany and France are expected to be settled—the first named before Christmas and the second in the spring.

Telephone Messages in Paris.—An innovation was introduced here at the beginning of the month. Anybody can send from a telephone call office, or, if a subscriber, from his house, a message to one of eight selected telegraph offices in Paris. This will be written out there and conveyed to the address named in the message. It must not contain more than 100 words, and is charged at the rate of half a franc.

City and South London Railway.—We notice that the magistrate of the Lambeth Court has decided against the railway company in the action brought by the London County Council to compel them to set back their station

buildings to the building line. An order was made for the demolition of so much of the stations as projected beyond the line, but on the application of the Company a case was stated for consideration in the superior courts.

Presentation.—On Saturday last the employés in the electrical department of the Clydebank Shipyard Company presented the foreman, Mr. W. Bass, with a silver chain and appendage with inscription. The presentation was made at Stark's Restaurant, Clydebank, by Mr. Young, electrician to the company. Mr. Bass is leaving Clydebank to act as foreman for a London firm, who are having several steamers built in Belfast which are to be electrically lighted.

Woking.—The Woking Electric Supply Company, the starting of whose plant we noticed last week, state that agreements have been made for supplying between 600 and 700 lamps, and it is anticipated that the remaining 1,400 lamps will very soon be applied for, and that the profit, after paying working expenses, and making all proper deduction for depreciation of plant and buildings, will be sufficient to pay a dividend of 11 per cent. upon a capital of £12,000.

Stockport's compulsory area under the Corporation order (when obtained) is to consist of St. Petersgate Bridge, from the north side of Little Underbank to the Market-place, the Market-place, Little Underbank, Lower Hillgate—from little Underbank to Dumville's-brow, being about 95 yards north of the north side of Wellington-street, Great Underbank—from Little Underbank to Bridge-street, Bridge-street, and Heaton-lane—from Bridge-street to Brook-street.

Much Needed.—A daily paper speaking of the lighthouse at Cape Villano which should have warned the officers of H.M.S. "Serpent" of their position before it was too late, but which is far too feeble to be of any good, says that the Spanish lighthouse administration have proposed the establishment of a first-class lighthouse with electric light in its place. The project is under the consideration of the engineer of the province of Corunna, who is to furnish a report as soon as possible.

Windsor Castle.—From the paragraphs which have been flitting around in the papers, one would think that Windsor Castle had only just been lighted electrically, whereas Mr. Massey introduced incandescents years ago. A very small portion of the castle was lighted to begin with, and other rooms have been wired from time to time, the latest being the library. At the present rate of progress it will take some years before the whole of the "venerable pile" is up to date so far as illuminants go.

Chain Motors.—One of the latest motors designed by Mr. Albion T. Snell for coal mines obviates the disadvantages of the excessive weight of the locomotive needed to gain sufficient friction on stiff inclines, by having a continuous chain gear. The chain is fixed at each end of the gallery, and passes around the sprocket wheel of the electric motor on the locomotive, thus hauling the train of trucks along. This arrangement has been found far more practical in special cases than the simple locomotive for hauling.

Scarborough.—The Town Council having called in Mr. Bernard Drake (Drake and Gorham) to report on (1) the best system of lighting to adopt; (2) the local conditions under which the light must be supplied; (3) the question of street lighting; (4) the attitude of the Board of Trade; and (5) the position generally of the Corporation under the provisional order which they obtained in 1883, have decided, in accordance with Mr. Drake's conclusions, to obtain a new order containing the model clauses approved by the Board of Trade.

Photography and Electrical Theories.—In the course of his presidential address to the Society of Arts, on Wednesday evening, Sir R. Webster, speaking of photography and its possibilities, especially in the direction of coloured photographs, said: "It was interesting to note that the theories of Clerk Maxwell with regard to electricity, and the experiments of Prof. Oliver Lodge and Sir Archibald Campbell, might verify the somewhat crude suggestions of M. Claudet as to the real agency which operated in producing a photographic image."

Mine Lighting.—Herr P. Ringsdorff has just fitted up an installation at the "Gustave" coal mines in Germany. Eight arcs and 100 incandescents light the engine-room, offices, and other departments above ground. We give in another column extracts from an address to the Manchester Geological Society by Mr. J. S. Burrows, on the subject of lighting and power transmission for mines. With reference to his remarks as to coal-cutting machines, unless we are misinformed it will not be long before he will have an opportunity of seeing one at work in his district.

Catalogue of Technical Books.—The Britannia Company, of Colchester, have issued a handy "Buyer's Guide to Technical Books in the Mechanical Arts." The books are indexed alphabetically under their titles, and arranged in an alphabetical classification according to the subject dealt with. At the end is an index of authors' names, so that the convenience of those using the catalogue has been very carefully studied. The price post free is 6d., and we have no doubt that this little compilation, which has arisen out of the needs of the company itself, will prove useful to many of our readers.

Are Clinkers Trade Refuse?—The St. Martin's Vestry said they were, and demanded extra payment for removing them. The Hotel Metropôle proprietors said nay, and were hauled over the coals in the law courts to defend their position. It has now been definitely settled that clinkers, even though formed in boilers which are used to supply steam for (*inter alia*) electric light machinery, come under house refuse and must be removed by the Vestry. For hotels and other business houses having their own engines and boilers this is an important and reassuring termination to an obstinately contested lawsuit.

Liverpool Overhead Railway.—Work on this, the first overhead electric railway, is progressing. The line, when completed, will be 5¾ miles long. The foundations have been put in for two miles, and the columns have been erected for over a mile, while three-quarters of a mile of the permanent way has been completed. The most difficult part of the work has been got over, and it is expected that the foundations and columns of the northern section will be completed up to Nicholas's Church by February next. The work on the southern section is also about to be commenced. The line will be worked by electric locomotives.

Cable Communication with Lightships.—It is stated that the German Post Office have offered to have one of Captain Harrsen's patent cables (or rather, we suppose, the patent means of connecting it with the lightships, wherein all the difficulty in this class of work lies) laid and tried at its own expense. Experiments of this

nature have been made on the English coast, but, so far, the Trinity House does not seem to have been satisfied as to the practicability of the devices used to prevent the cable kinking. If Captain Harrsen and the German Post Office make a success of the proposed trials they will have conferred a boon on mariners.

Manchester-Square Station.—The latest station of the Metropolitan Electric Supply Corporation at Manchester-square is more complete in many respects than their Sardinia-street station, more especially, perhaps, in respect to that important part of dynamo machinery—the steam-piping. The arrangement of the steam-piping at Manchester-square has been most carefully planned out so that the best use is made, and a duplicate path is always in force in case of accident, and the credit of this part of the work should be given where it is due, to Mr. Rosenthal, London manager of Messrs. Babcock and Wilcox, whose plans have been adopted after approval by the company's engineer.

Birkbeck Literary and Scientific Institution.—This institution held its sixty-seventh annual meeting on Wednesday, when the chair was taken by the Right Hon. the Earl of Northbrook, and the prizes were distributed to the successful students by Sir John Lubbock. Speeches were made by various gentlemen during the evening, and special attention was called to the importance of obtaining a thorough knowledge of electricity and electrical engineering. Reference was made to the great progress which had been made in electricity as a motive power, and the prospect of its still greater advancement in the immediate future, and the students were recommended to obtain as thorough a knowledge of the science as possible.

Paris.—The streets of Paris have been in a great state of upheaval for the last month or so. At all corners, and down many main boulevards, deep trenches are cut, and barricades of a more peaceful kind than seen in other years have stopped the progress of the promenaders. The Popp Company seems most active in these undertakings, though other companies are also engaged. A Parisian comic paper issues a cartoon showing the map sellers of Paris selling maps with the streets "still passable" painted in red. The systems mostly favoured are huge bare copper cables, slung on china insulators, as in Crompton's system—and also large and heavily-insulated cables, buried direct in the dry brickdust-like soil on which Paris seems to be built.

City Lighting.—At the last meeting of the Commissioners of Sewers, the chief clerk read a letter from Mr. F. Kite, who had been instructed by the Laing, Wharton, and Down Syndicate to state that they had abandoned their intention of proceeding with their application to the Board of Trade for a provisional order for the west district. The decision to put the lighting of this district open to tender had placed his clients in a somewhat difficult position, inasmuch as their accepted terms and prices for the east district had already become public property, and in consequence they considered that they were placed at a disadvantage in competing with other firms who were already in possession of that knowledge. The letter was referred to the Streets Committee.

Discontinuance of the Northfleet Electric Railway.—It has been decided to discontinue running the electric tramway on the series electrical conduit system at Northfleet, after having been in operation for the last 18 months The line was established, as is well known, mainly for demonstrative purposes, and its object having now been obtained there is no further reason for incurring the large expense necessitated by the smallness of the local traffic, and the heavy rental and charges imposed by the Gravesend, Rosherville, and Northfleet Tramway Company, through whom the parliamentary powers were obtained. Careful accounts have been kept of the cost of running for the last six months, and from these, when audited, the actual cost of motive power of the series system on this line will be made public.

Telephone in the West of England.—We have more than once called attention to the enterprise of the management of the Western Counties Telephone Company, and have pleasure in again recording extensions and concessions which offer further testimony in this direction. According to a request of the Plymouth Chamber of Commerce, the company have made arrangements to establish a signal station on Rame Head, from which vessels will be reported by telephone to Plymouth. The station should be working in a few weeks. The Devon and Cornwall Homœopathic Dispensary and Cottage Hospital have been connected with the Plymouth exchange free of charge. The trunk line to Plympton, Ivybridge, and Avonwick has been converted into a metallic instead of earth circuit. The company are now prepared to put residents at Plympton in connection with the exchange system at the same rates which are in operation in the Three Towns, making no extra charge for speaking over their trunk line to Plymouth, and *vice versâ*. It is also their intention to establish a similar service in the neighbourhood of Crown Hill early in the New Year. A call office is to be opened at Laira in a few weeks.

Madame Tussaud's.—A reception and supper was given at Madame Tussaud's on Wednesday night, on the occasion of the inauguration of the electric light in this popular show-place, an account of the arrangements adopted being given elsewhere in full. A large company attended, and inspected with interest the waxen kings and queens, the notabilities of England, France, and Germany, and America, etc., here to be seen, under the glamour of the electric light. The added cleanliness, as well as the adaptability of the light, will prove a great boon to the proprietors. A magnificent scene, newly added, of the execution of Mary, Queen of Scots, was highly admired, both for its realism and its dramatic interest, vividly brought out by the rays of the electric lamps cunningly reflected from behind. The ghastly Chamber of Horrors has become more ghastly by the adoption of a number of green-tinted electric bulbs, which cast a gloomy hue over this haunt of ignoble reminiscences. A band of Switzers playing on zither and guitar added life and gaiety to the Upper Chamber, where gaily-dressed visitors seemingly mingled with the State procession of the Princes and Princess Royal, stationed in life-like attitudes and magnificent pageantry down the centre aisles.

The Institution Conversazione.—The annual *conversazione* of the Institution of Electrical Engineers was held by the President (Dr. John Hopkinson, F.R.S.) and Mrs. John Hopkinson at the galleries of the Institute of Painters in Water Colours, in Piccadilly, on Wednesday evening. To be at a *conversazione*, to see and chat with the well-known men of science, to make new friends and discuss electrical progress, and to listen to sweet music, is better than to read of such doings afterwards in technical papers. We will content ourselves, therefore, by hoping that all our readers who possibly could did attend, and in mentioning that among other notabilities there were present Sir Richard Webster, M.P., Sir Benjamin

Baker, Sir F. Pollock, Prof. Adams, F.R.S., Prof. Ayrton, F.R.S., Prof. Silvanus P. Thompson, D.Sc., Mr. W. H. Preece, F.R.S., Mr. Cecil Raikes, M.P., Postmaster-General, Mr. Graves, General Webber, Mr. William Crookes, F.R.S., Mr. J. W. Swan, General Festing, R.E., General Sir L. Nicholson, Mr. A. Siemens, General C. E. Webber, Sir Albert Cappel, Sir Frederick Bramwell, F.R.S., Dr. Gladstone, F.R.S., and Sir Frederick Abel, F.R.S. The band of the Coldstream Guards and the Bijou orchestra performed during the evening.

Edinburgh International Exhibition.—On Thursday week judgment was given in the second division of the Court of Session as to the petition of Messrs. Drysdale and Gilmour for judicial liquidation. The Court decided that the association must be wound up under voluntary liquidation, and confirmed the appointment of Mr. J. A. Robertson, chartered accountant, of Edinburgh, as liquidator. On Monday afternoon a meeting of the creditors of the Edinburgh International Exhibition was held in the chambers of the liquidator, Mr. J. A. Robertson, chartered accountant, for the purpose of appointing a committee to consult as to the realisation of the assets. In the course of the proceedings the liquidator said he had been advised, both by the agent in the liquidation and by counsel, that the British Linen Company Bank had no preference over the guarantee fund, and he was that day sending out a circular calling up the whole of the guarantee fund. A good many odds and ends had been sold on very favourable terms, railings and gates having sold at two-thirds of their original cost price. He had been advised by the agents and counsel that creditors who were guarantors must pay up their guarantee irrespective altogether of their claims against the exhibition. A committee for consultation was then appointed.

Bath.—At the last meeting of the Town Council, Mr. Sturges (chairman) moved the adoption of the report of the Special Electric Lighting Committee to the Surveying Committee, which included a copy of Major Cardew's report (*vide Electrical Engineer*, October 17th, p. 340). Mr. Sturges said he wished to compliment Mr. Massingham on the success of his installation. He also wished to compliment Bath on taking the position she had done in the matter of the electric light—that this important and beautiful improvement in the lighting of the town and houses was taken up so readily. There had been a succession of deputations to see how they got on, and he believed that in every instance they expressed their admiration and gratification at seeing the thing so successful. He advocated an independent inspection by a leading electrician. Mr. Massingham said he should be more satisfied if they employed an expert of the highest standing they could find—that was Mr. Preece—and he would move as an addition to the report that they should employ a scientist of sufficient eminence to investigate the whole of the works and report to the Council. In the course of the discussion which followed, Mr. A. Taylor suggested periodical inspection of the works. The report was unanimously adopted.

Alternating Plant in Lancashire.—An interesting example of the transmission of electric current for lighting by the alternating system has recently been carried out by Messrs. Mercier, Corlett, and Co., of Wigan, at the Golborne Colliery, Golborne (Lancs.). The plant has been designed to light the colliery both underground and on the surface, with the screening arrangements and sidings, and also to supply current for 150 lamps of 16 c.p. at the residence of the owner of the colliery, T. D. Gimké, Esq., Golborne Park, which is about 1½ miles away. The dynamo is a Mordey alternator of 25,000 watts at 2,000 volts, at the colliery, driven by a horizontal stationary engine, fitted with the Acme governor of Browett, Lindley, and Co. At the colliery itself there is a 300-light Swinburne "Hedgehog" transformer, which supplies the whole of the colliery circuit, consisting mainly of 16-c.p. and 32-c.p. lamps; the sidings being illuminated by three 200 and two 400-c.p. Sunbeam lamps. For the private house there is one 150-light "Hedgehog" transformer, and a 50-light transformer for the drive circuit, which is some quarter of a mile long. In the house there is a total of about 80 lamps of 10, 16, 32, and 50 c.p. suitably distributed, nearly all being cord suspensions and brackets. The long-distance circuit is mostly run overhead upon poles and suspension wires, being a cable of 7/19 vulcanised rubber insulation. In order to comply with the requests of local authorities, wherever the cable crosses a road, which it does in three places, it is laid underground in iron pipes suitably protected. The whole installation makes a very good example both of the efficacy of the electric light for colliery work, and its application to private uses by transmission by means of the alternating current.

Deptford.—Mr. W. S. Malcolm, assistant foundry manager at the Carron Works, has given the following account of the casting of the first of the 23-ton castings which are to form the feet of the magnet frames of the 10,000-h.p. Ferranti dynamo for Deptford station, which feet will have to carry the whole weight of the frames, amounting to many hundred tons: "As these measure some 12ft. by 10ft. by 6ft. 6in., and have each cast into their body the projecting ends of 11 magnets or blocks of soft iron 3ft. 3in. by 1ft. 6in. by 5in., and weighing in all about 4½ tons, some idea may be formed of the nature of the casting. The greatest difficulty the contractors have had to overcome in the manufacture of these magnet frames has been the securing into the casting in a thoroughly fast and trustworthy manner of these large blocks of soft iron, this being absolutely necessary owing to the nature of the forces brought to bear on the magnets when the dynamos are at work. Possibly, owing to the very unusual nature of the casting, the same difficulty may not previously have presented itself to founders in any case. All the ordinary methods of casting failed to secure the desired end, and very special and novel treatment indeed has had to be resorted to before a satisfactory solution of the difficulty has been found. What in ordinary circumstances would form the main core of the mould has built into its interior a light steel tank of the necessary form and dimensions to suit the magnets, and into this vessel the magnets project for about 2ft. of their length. You have thus at once a core fulfilling all the ordinary functions of such, and at the same time in itself a water-tight vessel surrounding the magnets. After the metal has been run into the mould and allowed to set, cold water is immediately passed through the tank or vessel and caused to circulate round the magnets, but not in contact with the cast iron, for a period of from two to four days. After this time, and during which the cast iron has been kept warm as long as possible, it is found that the magnets are firmly bound into the casting and practically form a part of it. As the contractors have already cast over 20 12½-ton castings on the same principle, only applied somewhat differently, the process may be said to have been subjected to a thorough test. In closing, I may state that the above process was introduced specially for the occasion, and has since been patented by me."

A GROSVENOR SQUARE INSTALLATION.

Of mansion-house electric lighting there are, briefly, two large classes, those which are connected to the public mains and those having their own generating machinery. Of the self-contained kind, most examples will naturally be found in country places, where connections to mains are impossible, while those supplied by companies will be town houses. But although it is unquestionably true that the inauguration of the various central stations in the West-end of London has enabled a large number of town houses to take their supply from the mains, and thus to obtain electric light which otherwise they would do without, yet there are a very considerable number of instances where the advantages of control and the absence of necessity for outside intervention or the supervision of a company or other causes, have induced the owners or leaseholders to put in their own plant, from engine and dynamos onwards. The advantages offered by the use of gas engines has been one great cause predisposing to this arrangement, which must prove a satisfactory sop to minds of gas companies, who watch with anxiety the continued progress of electric light amongst their best paying

Stockport Gas Engine, used at Grosvenor Square.

customers, but yet who, under the circumstances of a self-contained plant driven by gas, do not lose, while both the user himself and the electrical engineers benefit.

A very fine example of the use made of gas engines in a large private town installation is found in that of E. Cassells, Esq., of 48, Grosvenor-square, and the whole installation is very carefully arranged and carried out. The house itself is a very large and extensive building, and has recently been fitted up, practically regardless of cost, with white and satin wood fittings, with priceless silk tapestries, and with specially-designed ceilings, by Messrs. Collinson and Lock, of Oxford-street. This firm, early recognising the importance which the electric light is destined to have upon the interior decoration of English mansions, have organised a special department for electric light fitting, and have for some time engaged an electrical engineer of their own to superintend and carry out their work in this direction. This gentleman, Mr. T. Blackley, was for some time engaged with Messrs. Woodhouse and Rawson, and later held a responsible position in the now deceased Schanschieff Company. He has laid out and superintended the installation in question, and the neatness of the arrangements as well as the success of the lighting show that Messrs. Collinson and Lock have an engineer who can do their work with credit. Some idea of the extent of the work already done by this firm may be gathered when it is learnt that since they have started, some 18 months ago, they have already carried out more than £15,000 worth of electric lighting work amongst their customers.

At the Grosvenor-square installation one of the new type double-acting "Stockport" gas engines has been employed with very great satisfaction. We give herewith a view of this engine, from which it will be seen that it consists, in effect, of two ordinary gas engines coupled end to end—that is, a twin engine, with two exploding cylinders, both connected to the same crankshaft. This arrangement, though possibly using slightly more gas per horse-power than a single-acting engine of the same type, has undeniable advantages, having been specially designed for use in electric installations, and is eminently suited thereto on account of the great steadiness of running which it gives. The engine in question is a 14 h.p. nominal, working up to some 20 or 22 brake horse-power, and when driving direct or charging the accumulators the fluctuations are hardly noticeable on the ammeter, varying at an average of 80 amperes, from 78 to 82 amperes, and often for long runs together hardly shifting the needle. The engine is free from all complication of machinery. It is fired by the red-hot tube method, and the only working part besides the cylinders is a small knife-edge governor, which is both very sensitive and very light in working.

This engine drives a Crompton shunt-wound dynamo, capable of giving 120 amperes and 135 volts at 930 revolutions. This is connected by a Gandy belting direct to the driving pulley of the gas engine, and no flywheel is used on the dynamo. This plant, together with the tanks, switchboards, and accumulators, is placed in a small arched cellar under the house, and no noticeable vibration or noise is experienced outside the engine-room.

Switchboard used at Grosvenor-square.

The accumulators consist of two sets of 23L E.P.S. cells, charged at about 80 amperes, and from which 90 amperes or more is often taken out. They are covered with the granulated cork introduced by Messrs. Drake and Gorham, which is found to preserve the acid and prevent spraying. The tanks for the engines were made by Messrs. John Smeaton, Son, and Co., of Great Queen-street, and the engine itself was put down by the makers, Messrs. Andrew and Co., of Reddish, near Stockport. After a trial run of a day or two, the whole installation was run for a stretch of 40 hours without stopping, and again the day after for another run of 40 hours without stopping, which speaks well both for the engine and the dynamo, as well as for the general arrangement of the installation.

The switchboard used here is a very good and comprehensive one, of the type made by Messrs. Poole and White.

The arrangement will be seen from the illustration which we also give herewith. The switchboard is mounted upon slate, cut into three pieces, on the plan recommended by Mr. Musgrave Heaphy, of the Phoenix Fire Office, and is joined together with insulation between (neatly covered by brass strip) the better to guard against short-circuiting on the board itself. The connections are exactly repeated on each side to provide for either direct running from the dynamo to the lamps or from the accumulators to the lamps, or both together, and the connections not only are solidly and scientifically carried out, but embody some necessary precautional measures, and at the same time present a very handsome appearance. The bars down the middle are connected to the last seven cells of the battery, to allow for compensation in voltage, the other end of the battery being connected to the lamp circuit and to one brush of the dynamo. The other pole of the dynamo comes to the plug seen in the centre at the bottom—the plug answering uses to be afterwards mentioned. This plug communicates first with the bottom right-hand switch, which, when turned, sends the current through the fuse seen above it, then up the copper rods (which are bare,

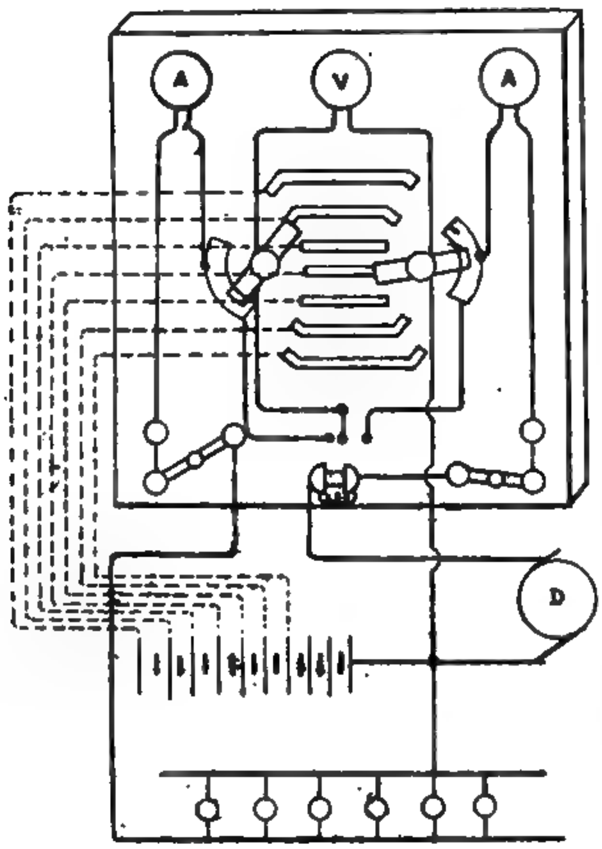

Diagram of Switchboard.

in air) to the Schuckert ampere-meter, and down again to the regulating switch handle in the centre of the board. This regulating switch puts in or cuts out, according to its position, one, two, three, up to seven extra cells, and the switch is so made that as it traverses from one bar to the other no cell is ever actually short-circuited nor is the circuit quickly broken, but the two minor switch pieces to the side, which move with the switch itself, shunt the cell momentarily through the thick German silver resistance wires which may be seen mounted as part of the switch, moving with it. The whole arrangement is repeated on the other half of the switchboard, but this other side is connected to the lamp circuit direct, and the regulation is then for discharge.

The ammeter in this circuit, of course, shows the strength of current coming from the cells. When the whole strength of the installation is required for ballroom or other purposes both switches are turned on, though, indeed, this is more often the case than otherwise, the dynamo so charging the batteries at the same time as it supplies a portion of the lights. When it is required to start the gas engine, the tube light is lighted and the gas turned on. Then the plug before mentioned is taken out and the switch turned, making the cells discharge through the dynamo, which acts as a motor, driving the gas engine till the explosions occur and the engine takes its load. The two parts of the plug are connected across by a thick resistance wire behind the board, which prevents too strong a rush of current from taking place from the cells. The voltmeter placed at the centre at the top has a double contact switch at the base of the board, for testing the voltage of either the cells or of the dynamo. Two incandescent pilot lamps show the strength of the light, and also serve to illuminate the instruments. The engine is usually run for about six hours a day in ordinary working.

The fittings of themselves are most handsomely carried out, nearly all being specially designed by Messrs. Collinson and Lock's designer, Mr. Webb, and a few being adaptations of Faraday's light and graceful holders and filagree work. The fittings comprised numerous pendants and brackets, and the most noticeable perhaps are sets of wreathed Old French candlesticks and also some small chased silvered panels with scroll edges and projecting arms for obscured globes, which are most happy in their effect when placed flat upon the silk tapestry over the mantels and around the rooms; and, again, some special figures, in heavily gilt and chased work, of classical angels, with extended wings and uplifted hands, gently holding the illuminated bulb, which depends from a short bracket arm to match from just above. So much is this last fitting appreciated that the room is to have a dozen in all of these elegant "angels of light" fitted between the windows.

The lights are for the most part 16 c.p., but many 32 and 50 c.p. lamps have been introduced, the total capacity being equal to 300 16-c.p. lamps. In the drawing-room and ballroom a perfect blaze of light is attempted, further aided by the whiteness of the walls and the furniture; here the 35 lamps distributed around the walls, and the two clusters of 10 lamps each down the centre, will make that portion of Grosvenor-square on a winter's night like a perfect lighthouse, throwing its rays into the gloomy square outside. The whole installation is carried out in the same thorough and well-finished manner, and gives great satisfaction in its employment.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

Lecture II.

(*Continued from page 436.*)

In order to study this question of leakage, and the relation of leakage to pull, still more incisively, I devised some time ago a small experiment, with which a group of my students at the Technical College have been diligently experimenting. Here (Fig. 43) is a horseshoe electromagnet. The core is of soft wrought iron, wound with a known number of turns of wire. It is provided with

Fig. 43.—Experiment on Leakage of Electromagnet.

an armature. We have also wound on three little exploring coils, each consisting of five turns of wire, only one, C, right down at the bottom, on the bend; another, B, right round the pole, close up to the armature; and a third, A, around the middle of the armature. The object of these is to ascertain how much of the magnetism which was created in the core by magnetising power of these coils ever got into the armature. If the armature is at a consider-

* Cantor lectures, delivered before the Society of Arts.

able distance away, there is naturally a great deal of leakage. The coil, C, around the bend at the bottom is to catch all the magnetic lines that go through the iron; the coil, B, at the poles, is to catch all that have not leaked outside before the magnetism has crossed the joint; while the coil, A, right around the middle of the armature, catches all the lines that actually pass into the armature and pull at it. We measure by means of the ballistic galvanometer and these three exploring coils how much magnetism gets into the armature at different distances, and are able thus to determine the leakage and compare these amounts with the calculations made, and with the attractions at different distances. The amount of magnetism that gets into the armature does not go by a law of inverse squares, I can assure you, but by quite other laws. It goes by laws which can only be expressed as particular cases of the law of the magnetic circuit. The most important element of the calculations, indeed, in many cases is the amount of percentage of leakage that must be allowed for. Of the magnitude of this matter you will get a very good idea by the result of these experiments following.

The iron core is 13 millimetres in diameter, and the coil consists of 178 turns. The first swing of the galvanometer when the current was suddenly turned on or off measures the number of magnetic lines thereby sent through, or withdrawn from, the exploring coil that is at the time joined to the galvanometer. The currents used varied from 0·7 of an ampere to 5·7 amperes. Six sets of experiments were made, with the armature at different distances. The numerical results are given in the following tables:

—	A	B	C
I.—With Weak Current (0·7 amperes).			
In contact	12,506	13,870	14,190
Armature distance, 1 mm.	1,552	2,163	3,786
" " 2 mm.	1,149	1,487	2,839
" " 5 mm.	1,014	1,081	2,028
" " 10 mm.	676	1,014	1,690
Removed	—	675	1,352
II.—Stronger Current (1·7 amperes).			
In contact	18,240	19,590	20,283
Armature distance, 1 mm.	2,570	3,381	5,408
" " 2 mm.	2,366	2,839	5,073
" " 5 mm.	1,352	2,299	5,949
" " 10 mm.	811	1,352	3,381
Removed	—	1,308	3,041
III.—Still Stronger Current (3·7 amperes).			
In contact	20,940	22,280	22,960
Armature distance, 1 mm.	5,610	7,568	11,831
" " 2 mm.	4,597	6,722	9,802
" " 5 mm.	2,569	3,245	7,436
" " 10 mm.	1,149	2,704	7,098
Removed	—	2,366	6,427
IV.—Strongest Current (5·7 amperes).			
In contact	21,980	23,660	24,040
Armature distance, 1 mm.	8,110	10,810	17,220
" " 2 mm.	5,611	8,464	15,886
" " 5 mm.	4,056	5,273	12,627
" " 10 mm.	2,029	4,057	10,142
Removed	—	3,581	9,795

These numbers may be looked upon as a kind of numerical statement of the facts roughly depicted in Figs. 31 to 34. The numbers themselves, so far as they relate to the measurements made (1) in contact, (2) with gaps of one millimetre breadth, are plotted out on Fig. 44; there being three curves, A, B, and C, for the measurements made when the armature was in contact, and three others, A_1, B_1, C_1, made at the one millimetre distance. A dotted line gives the plotting of the numbers for the coil C, with different currents, when the armature was removed.

On examining the numbers in detail, we observe that the largest number of magnetic lines forced round the bend of the iron core, through the coil C, was 24,040 (the cross-section being a little over one square centimetre), which was when the armature was in contact. When the armature was away, the same magnetising power only evoked 9,795 lines. Further, of those 24,040, 23,660 (or 98½ per cent.) came up through the polar surfaces of contact, and of those again 21,980 (or 92½ per cent. of the whole number) passed through the armature. There was leakage, then, even when the armature was in contact, but it amounted to only 7½ per cent. Now, when the armature was moved but one millimetre (*i.e.*, $\frac{1}{25}$th of an inch) away, the presence of the air gaps had this great effect, that the total magnetic flux was at once choked down from 24,040 to 17,220. Of that number only 10,810 (or 47 per cent.) reached the polar surfaces, and only 8,110 (or 47 per cent. of the total number) succeeded in going through the armature. The leakage in this case was 53 per cent. With a two millimetre gap, the leakage was 65 per cent. when the strongest current was used. It was 68 per cent. with a five millimetre gap, and 80 per cent. with a 10 millimetre gap. It will further be noticed that whilst a current of 0·7 ampere sufficed to send 12,506 lines through the armature when it was in contact, a current eight times as strong could only succeed in sending 8,110 lines when the armature was distant by a single millimetre.

Such an enormous diminution in the magnetic flux through the armature consequent upon the increased reluctance and increased leakage occasioned by the presence of the air gaps, proves how great is the reluctance offered by air, and how essential it is to have some practical rules for calculating reluctances and estimating leakages to guide us in designing electromagnets to do any given duty.

The calculation of magnetic reluctances of definite portions of a given material are now comparatively easy, and, thanks to the formulæ of Prof. Forbes, it is now possible in certain cases to estimate leakages. Of these methods of calculation an abstract will be given in the appendix of this lecture. I have, however, found Forbes's rules, which were intended to aid the design of dynamo-machines, not very convenient for the common cases of electromagnets, and have, therefore, cast about to discover some more apposite mode of calculation. To predetermine the probable percentage of leakage one must first distinguish between those magnetic lines which go usefully through the armature, and help to pull it, and those which go astray through the surrounding air and are wasted so far as any pull is concerned. Having set up this distinction, one then needs to know the relative magnetic conductance, or permeance, along the path of the useful lines and that along the innumerable paths of the wasted lines of the stray field. For, as every electrician accustomed to the problem of shunt circuits will recognise, the quantity of lines that go respectively along the useful and wasteful paths will be directly proportional to the conductances, or permeances, along those paths, or will be inversely proportional to the respective resistances along those paths. It is customary in electromagnetic calculations to employ a certain coefficient of allowance for leakage, the symbol for which is v, such that when we know the number of magnetic lines that are wanted to go through the armature we must allow for v times as many in the magnet core. Now, if u represents permeance along the useful path, and w the permeance of all the waste paths along the stray field, the total flux will be to the useful flux as $u+w$ is to u. Hence the coefficient of allowance for leakage

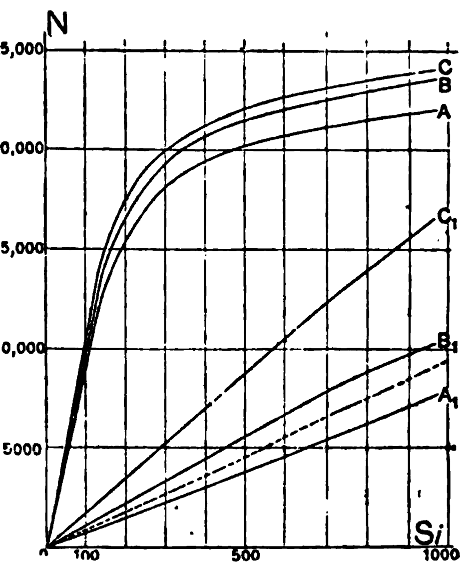

FIG. 44.—Curves of Magnetisation Plotted from Preceding.

v is equal to $u+w$ divided by u. The only real difficulty is to calculate u and w. In general u is easily calculated; it is the reciprocal of the sum of all the magnetic reluctances along the useful path from pole to pole. In the case of the electromagnet used in the experiments last described, the magnetic reluctances along the useful path are three in number—that of the iron of the armature, and those of the two air gaps. The following formula is applicable:

$$\text{reluctance} = \frac{l_1}{A_1 \mu_1} + \frac{2 l_2}{A_2},$$

if the data are specified in centimetre measures, the suffixes 1 and 2 relating respectively to the iron and to the air. If the data are specified in inch measures the formula becomes

$$\text{reluctance} = 0{\cdot}3132 \left\{ \frac{l''_1}{A''_1 \mu_1} + \frac{2 l''_2}{A''_2} \right\}.$$

But it is not so easy to calculate the reluctance (or its reciprocal, the permeance) for the waste lines of the stray field, because the paths of the magnetic lines spread out so extraordinarily and bend round in curves from pole to pole.

Fig. 45 gives a very fair representation of the spreading of the lines of the stray field that leaks across between the two limbs of a horseshoe electromagnet made of round iron. And for square iron the flow is much the same, except that it is concentrated a little by the corners of the metal. Forbes's rules do not help us here. We want a new mode of considering the subject.

The problems of flow, whether of heat, electricity, or of magnetism, in space of three dimensions, are not among the most easy of geometrical exercises. However, some of them have been worked out, and may be made applicable to our present need. Consider, for example, the electrical problem of finding the resistance which an indefinitely extended liquid (say, a solution of sulphate of copper of given density) offers when acting as a conductor of electric currents flowing across between two indefinitely long parallel cylinders of copper. Fig. 45 may be regarded as

representing a transverse section of such an arrangement, the sweeping curves representing lines of flow of current. In a simple case like this it is possible to find an accurate expression for the resistance (or for the conductance) of a layer or stratum of unit thickness. It depends on the diameters of the cylinders, on their distance apart, and on the specific conductivity of the medium. It is not by any means proportional to the distance between them, being, in fact, almost independent of the distance, if that is greater than 20 times the perimeter of either cylinder. Neither is it even approximately proportional to the perimeter of the cylinders except in those cases when the shortest distance between them is less than a tenth part of the perimeter of either. The resistance for unit length of the cylinders is, in fact, calculated out by the rather complex formula—

$$R = \frac{1}{\pi \mu} \text{log. nat. } h\,;$$

Where
$$h = \frac{2a}{b + 2a - \sqrt{b^2 + 4ab}}\,;$$

the symbol a standing for the radius of the cylinder; b for the shortest distance separating them; μ for the permeability, or in the electric case the specific conductivity of the medium.

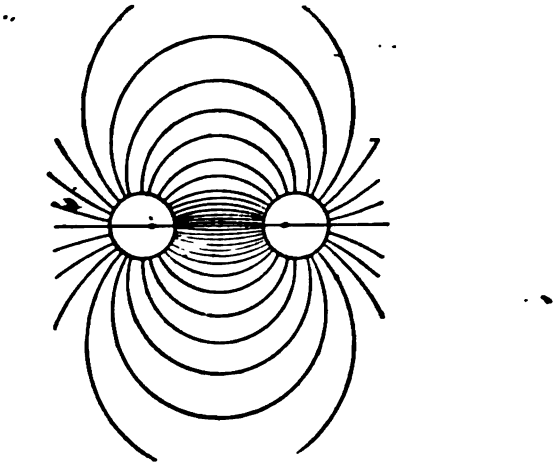

FIG. 45.—Curves of Flow of Magnetic Lines in Air from one Cylindrical Pole to another.

Now, I happened to notice, as a matter that greatly simplifies the calculation, that if we confine our attention to a transverse layer of the medium of given thickness, the resistance between the two bits of the cylinders in that layer depends on the ratio of the

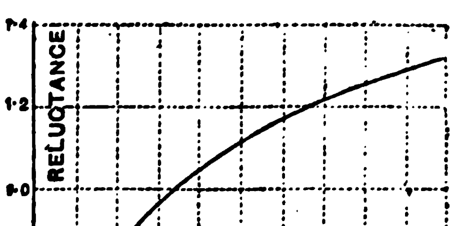

FIG. 46.—Diagram of Leakage Reluctances.

shortest distance separating them to their periphery, and is independent of the absolute size of the system. If you have the two cylinders an inch round, and an inch between them, then the resistance of the slab of medium (of given thickness) in which they lie will be the same as if they were a foot round and a foot apart. Now that simplifies matters very much, and thanks to my friend and former chief assistant, Dr. R. Mullineux Walmsley, who devoted himself to this troublesome calculation, I am able to give you, in tabular form, the magnetic resistance within the limits of proportion that are likely to occur.

The numbers from columns 1 and 2 of Table VII. are plotted out graphically in Fig. 46, for more convenient reference. As an example of the use of the table we will take the following:

EXAMPLE.—Find the magnetic reluctance and permeance between two parallel iron cores of 1in. diameter and 9in. long, the least distance between them being 2⅜in. Here $b = 2·375$; $p = 3·1416$ $b \div p = 0·756$. Reference to the table shows (by interpolation) that the reluctance and permeance for unit thickness of slab are respectively 0·183 and 5·336. For 9in. thickness, they will therefore be 0·021 and 48·02 respectively.

When the permeance across between the two limbs is thus approximately calculable, the waste flux across the space is estimated by multiplying the permeance so found by the *average* value of the difference of magnetic potential between the two limbs. And this, if the yoke which unites the limbs at the lower end is of good solid iron, and if the parallel cores offer little magnetic reluctance as compared with the reluctance of the useful paths, or of that of the stray field, may be simply taken as half the ampere-turns (or, if centimetre measures are used, multiply by 1·2566).

TABLE VIII.—Magnetic Reluctance of Air between Two Parallel Cylindrical Limbs of Iron.

$\frac{b}{p}$ Ratio of least distance apart to perimeter.	Magnetic reluctance in C.G.S. units = the magneto-motive force ÷ total magnetic flux.		Magnetic reluctance in inch units = the ampere-turns ÷ the total magnetic flux. Slab = 1in. thick.	
	Reluctance.	Permeance.	Reluctance.	Permeance.
0·1	0·2461	4·063	0·0771	12·968
0·2	0·3404	2·938	0·1066	9·377
0·3	0·4084	2·449	0·1280	7·815
0·4	0·4628	2·161	0·1450	6·897
0·5	0·5084	1·967	0·1593	6·278
0·6	0·5479	1·825	0·1717	5·825
0·8	0·6140	1·629	0·1924	5·198
1·0	0·6681	1·497	0·2093	4·777
1·2	0·7144	1·400	0·2238	4·571
1·4	0·7550	1·324	0·2365	4·228
1·6	0·7903	1·265	0·2476	4·039
1·8	0·8220	1·217	0·2575	3·883
2·0	0·8511	1·202	6·2667	3·750
4·0	1·0500	0·952	0·3290	3·040
6·0	1·1710	0·854	0·3669	2·726
8·0	1·2624	0·792	0·3955	2·528
10·0	1·3250	0·755	6·4151	2·409

In Table VIII. unit length of cylinders is assumed (one centimetre in columns two and three, 1in. in columns four and five), the flow of magnetic lines being reckoned as in a slab of infinite extent and of unit thickness. Symbols: p = perimenter of cylinder, b = shortest distance between cylinders. In columns two and three the unit reluctance is that of a centimetre cube of air. In columns four and five the unit reluctance is so chosen (as in the rest of these lectures wherever such measures are used) that the reduction of ampere-turns to magneto-motive force by multiplying by $4\pi \div 10$ is avoided. This will make the reluctance of the inch cube of air equal to $10 \div 4\pi \div 2·54 = 0·3132$, and its permeance as 3·1931.

The method here employed in estimating the reluctance of the waste field is, of course, only an approximation, for it assumes that the leakage takes place only in the planes of the slabs considered. As a matter of fact, there is always some leakage out of the planes of the slabs. The real reluctance is always, therefore, somewhat less, and the real permeance somewhat greater than that calculated from Table VIII.

For the electromagnets used in ordinary telegraph instruments the ratio of b to p is not usually very different from unity, so that for them the permeance across from limb to limb per inch length of core is not very far from 5·0, or nearly twice the permeance of an inch cube of air.

We are now in a position to see the reason for a curious statement of Count Du Moncel which for long puzzled me. He states that he found, using distance apart of one millimetre, that the attraction of a two-pole electromagnet for its armature was less when the armature was presented laterally than when it was placed in front of the pole-ends, in the ratio of 19 to 31. He does not specify in the passage referred to what was the shape of either the armature or the cores. If we assume that he was referring to an electromagnet with cores of the usual sort—round iron with flat ends, presumably like Fig. 11—then it is evident that the air gaps, when the armature is presented sideways to the magnet, are really greater than when the armature is presented in the usual way, owing to the cylindric curvature of the core. So, if at equal measured distance the reluctance in the circuit is greater, the magnetic flux will be less and the pull less.

It ought also now to be evident why an armature made of iron of a flat rectangular section, though when in contact it sticks on tighter edgeways, is at a distance attracted more powerfully if presented flatways. The gaps, when it is presented flatways (at an equal least distance apart) offer a lesser magnetic reluctance.

Another obscure point also becomes explainable—namely, the observations by Lenz, Barlow, and others, that the greatest amount of magnetism which could be imparted to long iron bars by a given circulation of electric current was (nearly) proportional, not to the cross-sectional area of the iron, but to its surface. The explanation is this. Their magnetic circuit was a bad one, con-

sisting of a straight rod of iron and of a return path through air. Their magnetising force was being in reality expended not so much on driving magnetic lines through iron (which is readily permeable), but on driving the magnetic lines through air (which is, as we know, much less permeable), and the reluctance of the return paths through the air is—when the distance from one to the other of the exposed end parts of the bar is great compared with its periphery—very nearly proportional to that periphery—that is to say, to the exposed surface.

Another opinion on the same topic was that of Prof. Müller, who laid down the law that for iron bars of equal length and excited by same magnetising power, the amount of magnetism was proportional to the square root of the periphery. A vast amount of industrious scientific effort has been expended by Dub, Hankel, Von Feilitzsch, and others on the attempt to verify this "law." Not one of these experimenters seems to have had the faintest suspicion that the real thing which determined the amount of magnetic flow was not the iron but the reluctance of the return path through air. Von Feilitzsch plotted out the accompanying curves, Fig. 47, from which he drew the inference that the law of the square root of the periphery was established. The very straightness of these curves show that in no case had the iron become so much magnetised as to show the bend that indicates approaching saturation. Air, not iron, was offering the main part of the resistance to magnetism in the whole of these experiments. I draw from the very same curves the conclusion that the magnetisation is not proportional to the square root of the periphery, but is more nearly proportional to the periphery itself; indeed, the angles at which the different curves belonging to the different peripheries rise show that the amount of magnetism is very nearly as the surface. Observe here we are not dealing with a closed magnetic circuit where section comes into account; we are dealing with a bar in which the magnetism can only get from one end to the other by leaking all round into the air. If, therefore, the reluctance of the air path from one end of the bar to the other is proportional to the surface, we should get some curves very like these; and that is

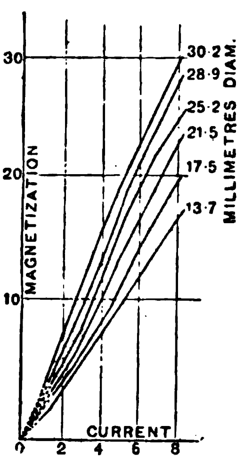

FIG. 47.—Von Feilitzsch's Curves of Magnetism of Rods of Various Diameters.

exactly what happens. If you have a solid, of a certain given geometrical form, standing out in the middle of space, the conductance which the space around it (or rather the medium filling that space) offers to the magnetic lines flowing through it, is practically proportional to the surface. It is distinctly so for similar geometrical solids, when they are relatively small as compared with the distance between them. Electricians know that the resistance of the liquid between two small spheres, or two small discs of copper immersed in a large bath of sulphate of copper, is practically independent of the distance between them, provided they are not within 10 diameters, or so, of one another. In the case of a long bar we may treat the distance between the protruding ends as sufficiently great to make an approximation of this law hold good. Von Feilitzsch's bars were, however, not so long that the average value of the length of path from one end surface to the other end surface, along the magnetic lines, was infinitely great as compared with the periphery. Hence the departure from exact proportionality to the surface. His bars were 9·1 centimetres long, and the peripheries of the six were respectively 94·9, 90·7, 79·2, 67·6, 54·9, and 42·9 millimetres.

It has long been a favourite idea with telegraph engineers that a long-legged electromagnet in some way possessed a greater "projective" power than a short-legged one—that, in brief, a long-legged magnet could attract an armature at a greater distance from its poles than could a short-legged one made with iron cores of the same section. The reason is not far to seek. To project or drive the magnetic lines across a wide intervening air gap requires a large magnetising force on account of the great reluctance, and the great leakage in such cases. And the great magnetising force cannot be got with short cores, because there is not, with short cores, a sufficient length of iron to receive all the turns of wire that are in such a case essential. The long-leg is wanted simply to carry the wire necessary to provide the requisite circulation of current.

We now see how, in designing electromagnets, the length of the iron core is really determined; it must be long enough to allow of the winding upon it of the wire which, without overheating, will carry the ampere-turns of exciting current which will suffice to force the requisite number of magnetic lines (allowing for leakage) across the reluctances in the useful path. We shall come back to this matter after we have settled the mode of calculating the quantity of wire that is required.

Being now in a position to calculate the additional magnetising power required for forcing magnetic lines across an air gap, we are prepared to discuss a matter that has been so far neglected—namely, the effect on the reluctance of the magnetic circuit of joints in the iron. Horseshoe electromagnets are not always made of one piece of iron bent round. They are often made, like Fig. 11, of two straight cores shouldered and screwed, or riveted into a yoke. It is a matter purely for experiment to determine how far a transverse plane of section across the iron obstructs the flow of magnetic lines. Armatures, when in contact with the cores, are never in perfect contact, otherwise they would cohere without the application of any magnetising force; they are only in imperfect contact, and the joint offers a considerable magnetic reluctance. This matter has been explained by Prof. J. J. Thomson and Mr. Newell, in the Cambridge Philosophical Society's *Proceedings*, in 1887; and recently more fully by Prof. Ewing, whose researches are published in the *Philosophical Magazine* for September, 1888. Ewing not only tried the effect of cutting and of facing up with true plane surfaces, but used different magnetising forces, and also applied various external pressures to the joint. For our present purpose we need not enter into the questions of external pressures, but will summarise the results which Ewing found when his bar of wrought iron was cut across by section planes, first into two pieces, then into four, then into eight. The apparent permeability of the bar was reduced at every cut.

TABLE IX.—Effect of Joints in Wrought-iron Bar (not compressed).

H	B				Mean thickness of equivalent air space for one cut.		Thickness of iron of equivalent reluctance per cut.	
	Solid.	Cut in two.	In four.	In eight.	Centimetres.	Inches.	Cm.	In.
7·5	8,500	6,900	4,809	2,600	0·0036	0·0014	4	1·57
15	13,400	11,550	8,900	5,550	0·0030	0·0012	2·53	1·00
30	15,350	14,550	12,940	9,800	0·0020	0·0008	1·10	0·463
50	16,400	15,950	15,000	13,300	0·0013	0·0005	0·43	0·139
70	17,100	16,840	16,120	15,200	0·0009	0·0004	0·22	0·067

Suppose we are working with the magnetisation of our iron pushed to about 16,000 lines to the square centimetre (*i.e.*, about 150lb. per square inch, traction), requiring a magnetising force of about H = 50, then, referring to the table, we see that each joint across the iron offers as much reluctance as would an air gap 0·0005 of an inch in thickness, or adds as much reluctance as if an additional layer of iron about one-sixth of an inch thick had been added. With small magnetising forces the effect of having a cut across the iron with a good surface on it is about the same as though you had introduced a layer of air one six-hundredth of an inch thick, or as though you had added to the iron circuit about 1in. of extra length. With large magnetising forces, however, this disappears, probably because of the attraction of the two surfaces across that cut. The stress in the magnetic circuit, with high magnetic forces running up to 15,000 or 20,000 lines to the square centimetre, will of itself put on a pressure of 130lb. to 230lb. to the square inch, and so these resistances are considerably reduced; they come down, in fact, to about one-twentieth of their initial value. When Ewing specially applied compressing forces, which were as large as 670lb. to the square inch, which would of themselves ordinarily, in a continuous piece of iron, have diminished the magnetisability, he found the diminution of the magnetisability of iron itself was nearly compensated for by the better conduction of the cut surface. The old surface, cut and compressed in that way, closes, as it were, magnetically up—does not act like a cut at all; but at the same time you lose just as much as you gain, because the iron itself becomes less magnetisable.

(*To be continued.*)

GENERAL POST OFFICE.

Yesterday, the Postmaster-General laid the memorial-stone of the new General Post Office (North), which is to be erected on a site between Angel-street and St. Martin's-le-Grand. The ceremony was witnessed by the Post Office officials and others including Mr. Tanner, of H.M.'s Board of Works (the architect), and Mr. Chappell (the builder).

The Postmaster-General delivered an interesting address, dealing with the progress made in his department. Among other things he pointed out that in 1871 the number of telegrams was nearly ten millions, in 1889 it was 62½ millions—that was to say, that in 18 years the number had increased by 500 or 600 per cent. He concluded by a prophecy that if the business of the department increased at its present rapid rate, the next century would see the erection of a General Post Office South.

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

THE FIRE AT THE LONDON ELECTRIC.

It is best to get the whole truth of any matter, and in these days of the electric lighting industry it is especially necessary to get at the very root of anything that seems damaging to that industry. More or less troublesome and annoying breakdowns are certain to arise where machinery is largely used, but we have always held, and we still hold, the view that electricity is the safest illuminant that can be used, whether considering life, health, or safety from fire. The fire at the station of the London Electric Company, near Bond-street, came as a surprise, but a careful ascertainment of the facts at first hand puts a very different complexion on the matter to what might be surmised without any investigation. What we have to say relates principally to matters of fact—if conclusions or deductions are to be drawn, here are the broad facts, and readers must draw conclusions for themselves.

It is well known that the London Electric Supply Company has grown out of the original Grosvenor Gallery installation. For a time that installation had to contend against many and varied troubles. Then came Mr. Ferranti, who put the thing square, and business grew, grew to a greater extent than could be grappled with from this centre. The inception of the Deptford central station came, and the work of preparation has been going on there continuously for many months. During this latter period legal proceedings have been carried on, ending in an injunction, which finally caused a hurried clearance of the Grosvenor Gallery installation, perhaps a little time before Deptford was quite ready to take up the work. However, the change from Grosvenor Gallery to Deptford necessitated temporary arrangements, and the accident has arisen because of these temporary arrangements. Had the permanent apparatus been installed, it is exceedingly doubtful if the accident could have happened, and at any rate the lighting would have been continued almost without interruption. From Deptford, as the great centre, current will be sent to three distributing stations, and when all three are in working order, an accident, similar to this under discussion, at one can be provided for by the others. Unfortunately no distributing station is ready—the one where the accident took place was, as we have said, temporarily fitted, and some of the apparatus for the others was housed therein.

It seems that the fire was caused by the man in charge—an old hand, too—losing his presence of mind and doing just the very thing he ought not to have done. For some reason or other, instead of inserting a plug fairly and squarely, the man partly inserted the plug and then withdrew it, and an arc followed. Still, the insertion of the plug would have prevented any accident, or the turning of a switch within reach would have cut off the conductors; but

neither the one nor the other act was performed. The arc was allowed to play its own sweet will, and the station was gutted by fire. Of course there were indiarubber-covered wires, pieces of timber, and other combustibles all over the place, owing to the transition character of the work. The station itself is fireproof, so only the contents suffered to any great extent. This being the only station of the company at work, the whole of their lighting is necessarily at a standstill. We have no hesitation in saying, however, that within a very few days, we should say before the end of the next week, apparatus will have been installed and the lighting resumed.

It will be at once recognised that this accident has nothing whatever to do with this or that system. It has much to do with the personal equation of workmen. We may go so far as to say that in discussing this affair with Mr. Ferranti, he was good enough to explain that his permanent apparatus precluded the possibility of an arc proving dangerous. If an arc should occur, it will take place in the air, with nothing combustible near it, and even if it should fuse the brass bars, it would simply proceed to work its own destruction.

The accident, probably out of sheer cussedness, happened at the most inopportune moment, at a time of transition, at a time when all spare converters happened to be gathered together in that one particular place, and when everybody was intent upon getting out the old boilers preparatory to putting in the permanent fittings.

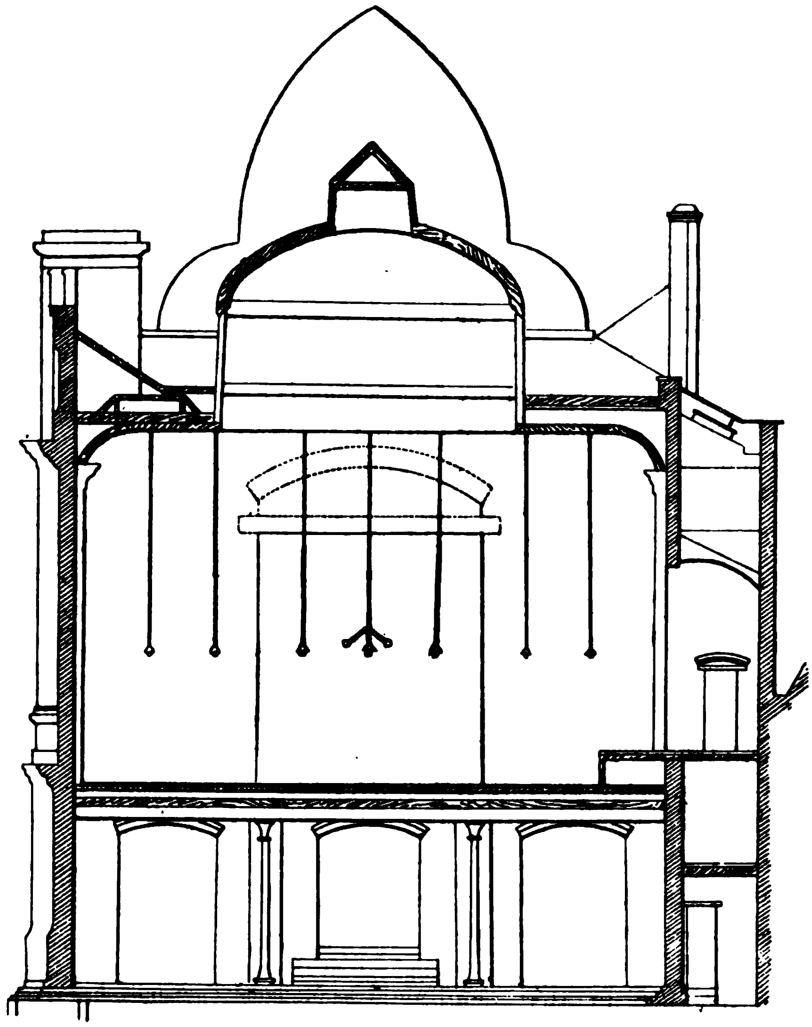
BYE-PRODUCTS.

What a pity it is that so much money, time, and—well, we were going to say sense, but perhaps it would be better to substitute the word brains—has been spent in endeavouring to make the bye-products of primary batteries the first consideration, and the current given out quite a secondary one. Knowing that primary batteries burning zinc are and must be expensive generators for lighting purposes, patentees, having, in many cases, we are afraid, a very shrewd eye to the main chance in the shape of company promotion, weigh in with bye-products as a counterbalance. Granting, for an instant, that a certain bye-product, say, oxide of zinc, is of commercial utility, and that a cell does (though it is usually on paper) produce a sufficient quantity of this to reduce the working expense, there yet remain two other very material questions unanswered. First, who will buy it? and second, how is it to be collected for sale? We may put aside the first question, because it really depends upon the answer to the latter. It seems to us that the use of primary batteries for lighting purposes will necessarily be very limited, and practically will remain confined to "temporary installations," as they are called, or country house work, where money is no object to the owner. But temporary installations are carried out by electrical engineers who, so far as our experience has gone, seem to prefer accumulators to primary batteries, and would not be likely to take up the latter for this class of work just to be able to sell a pound or two of oxide of zinc. As far as country houses are concerned, the difficulty of collecting the bye-products, even were they turned out by the battery in sufficient quantities to warrant collection, is a very practical bar to the imaginative flights of inventive genius. Besides, we have in London an establishment using enough batteries for a whole village, and where, if bye-products could be utilised as articles of merchandise and the cost of maintenance thereby reduced, we should be sure to find them being turned out by the ton—we mean, of course, the General Post Office. But, though Mr. Preece and his assistants know a thing or two, they do not yet know how to make bye-products pay, and, what's more, don't believe anybody else does. Nor do we.

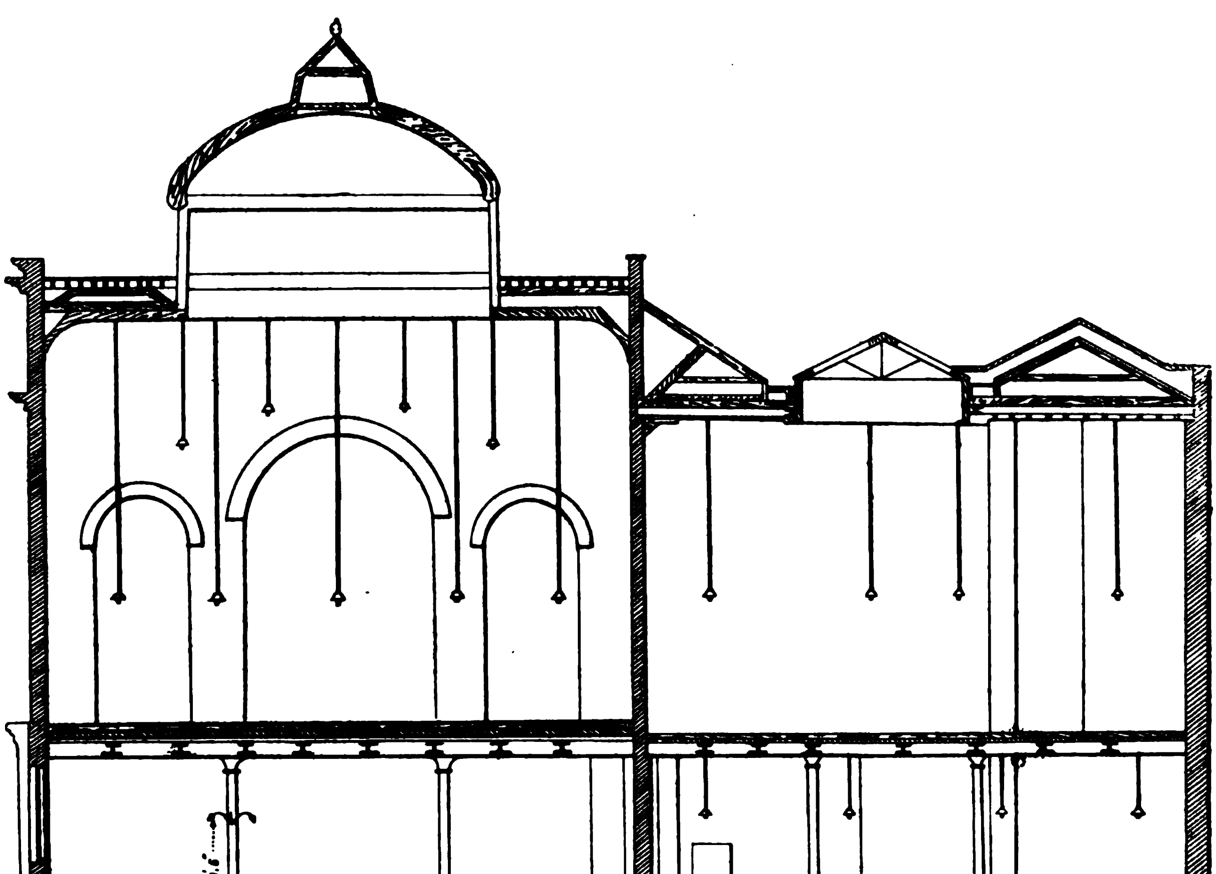
MADAME TUSSAUD'S.

The famous exhibition of criminal and historical waxwork figures at Baker-street, known throughout the civilised world as Madame Tussaud's, has recently been completely lighted up by the electric light. This institution, which is now almost as national in its character as the National Gallery and the Tower of London themselves, being one of the great sights of London, contains many historical portraits, relics, and costumes entirely unique and irreplaceable, and from this point of view alone is worthy of special care in preservation. But, besides this, it is both a most valuable property in its fame and in its wax and other treasures, a show-house surpassing any picture gallery or theatre in monetary value, and also a public place of visit and resort. On all of these counts the question of danger from fire or from panic has to be eliminated to the utmost extent possible by the most careful consideration and arrangement—from fire on account of the inflammable (or, perhaps, meltable) nature of the contents, and from panic in case of even a momentary extinction of light, as from the scattered nature of the exhibits they are liable to destruction by careless movements, or from ignorant persons fancying the imitation jewels and valuables to be real and snatching at them if any pretext were offered. At the same time, the crowds of visitors themselves deserve not less consideration than in the best arranged theatre.

The directors of "Madame Tussaud's" have, therefore, in determining to introduce the electric light throughout, placed the arrangement of the plant in the hands of Mr. Gisbert Kapp, who has designed the installation in full consideration of these circumstances, and we think the Tussaud installation, which we fully illustrate herewith, will be found to present an example of the very best attainable in the way of safety and thoroughness in electric lighting. The *desiderata* which Mr. Kapp has here set himself to carry out are—(1) entire duplication of plant sufficient each to supply the inside lighting, (2) duplication of storage batteries sufficient to run half the lights, (3) absolute guarantee against entire extinction of light either by failure of one or both engines or dynamos, or one or both storage batteries, (4) absolute guarantee against danger from fire by bad joints now or in the future, and (5) absolute absence from vibration from the engine. It will be interesting to describe how these *desiderata* are successfully carried out in the installation, which, though publicly inaugurated on



Madame Tussaud's.—Section.



Madame Tussaud's.—Section.

Wednesday last, has been practically running in more or less complete condition for some little time. The contractors selected in close competition to carry out Mr. Kapp's designs were Messrs. Drake and Gorham.

Plant.

The plant consists of two 16-h.p. nominal Otto gas engines, driving two 20-kilowatt shunt-wound continuous-current dynamos made by Johnson and Phillips, running at a speed of 650 revolutions at a voltage to vary—according to whether charging or supplying direct—from 110 to 140 volts. When running direct, the pressure at the dynamo is 112 volts; and when charging, usually about 140 volts. The dynamos are regulated by rheostats on the shunt circuit.

There are two main batteries of 112 E.P.S. cells, 23L type, of a joint capacity of 1,000 ampere-hours, and a small supplementary battery of 240 ampere-hours, 11L type, to supply the "panic" circuit to be described further on.

Each gas engine and dynamo works separately, and is capable of supplying direct 160 amperes, just equal to the current necessary for the whole inside lights. Each gas engine will therefore, on emergency, light the exhibition.

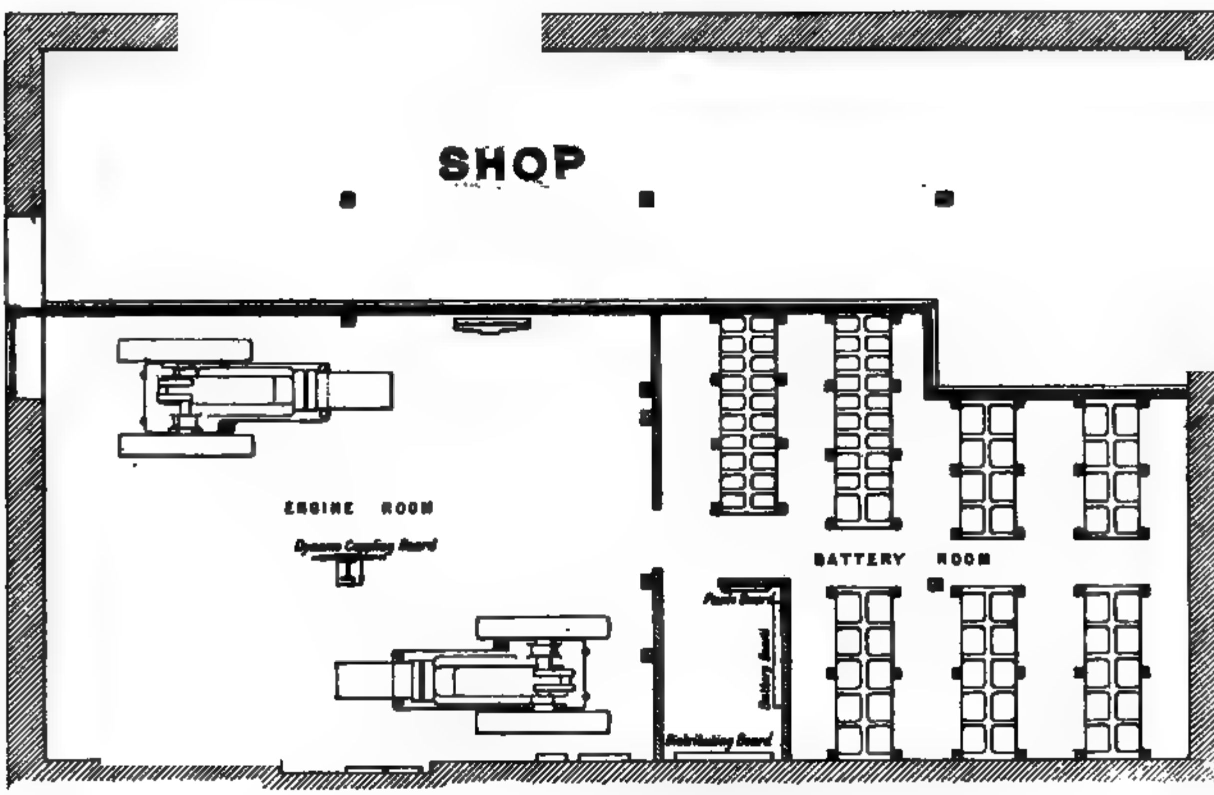
Foundations.

Both on account of the exhibition itself, and also on account of the artists employed for designing costumes and making the models, whose studios are immediately over the engine-room, the very greatest care has been necessary to prevent noise and vibration from the machinery. So successful have been the precautions taken that not the slightest tremor is to be noticed in the immediate room above, even with the most delicate brush painting. Very stringent measures have been taken by Mr. Kapp to ensure this result, which are fully shown in the sectional drawings. The arrangement shown is not by any means so costly as it would seem at first sight, the foundation only amounting to some £20.

In the first place, after excavation, a bed of concrete was laid over the floor 18in. thick, and carefully smoothed to a flat surface. Upon that was laid a layer of cocoa-nut fibre $\frac{3}{4}$in. thick, which was eventually compressed to less than $\frac{1}{4}$in. by the superincumbent mass. Next, to protect from moisture, the whole was covered with a sheet of 7lb. lead in one unbroken surface. Upon this was laid all over 9in. of brickwork, laid quite loose and open without mortar, to serve to take up any vibration, and break up the pulsations of the engine. Then finally upon this was laid the concrete foundation proper in one solid block or monolith 4ft. thick, extending over the whole engine-floor. Into this the bolts for the machinery were cemented in, and the foundation frames of the machinery itself grouted in. The whole machinery and foundation block is thus solidly connected together, and at the same time rests loosely and freely upon the floor itself through the brickwork, lead, and cocoa fibre. By this means the absolute immunity from vibration we have mentioned is attained, and without great cost.

Circuits.

For perfect security of light every room is served with three distinct circuits—two main circuits, and a "panic" circuit. Each room is so arranged that half of the lamps—every alternate lamp or group of lamps—is supplied by a different circuit direct from the dynamo-room. Besides this, every room has at least one lamp, or one group of lamps, supplied from a totally distinct circuit from the small supplementary or panic battery.



Madame Tussaud's.—Plan of Engine and Battery Room.

The space above the upper gallery around the dome is so narrow—about 2ft. 6in. only—that it would have been extremely difficult to make joints, and almost impossible to inspect, repair, or solder them afterward. The method was therefore adopted of having no soldered joints at all; every lamp, or every group of lamps, has been run with its unbroken wire, lead and return, direct from the ceiling rose to the fuse-box. There is, therefore, no danger from defective joints immediately or in the future to be feared. Each floor has therefore three circuits, and each circuit has its own set of fuse-boxes. These fuse-boxes are of Drake and Gorham's pattern, modified by having friction or plug fuses instead of screw fuses. Each positive circuit has a fuse-box distributing up the current to each lamp (or group of lamps) through its own fuse wire. In returning, the whole negatives are led to one terminal and served with one main fuse, thus making a double-pole cut-out to each circuit. These fuse-boxes are placed at convenient positions outside the staircases, and in case of a lamp going wrong its fuse can be inspected at once.

There are no switches anywhere, except in the engine-room, to prevent any tampering by the public or possibility of panic thereby.

The switchboard is placed in a compartment by itself in

DUNGANNON (IRELAND).

At the last meeting of the Dungannon Town Commissioners, Lord Ranfurly (the chairman) again brought forward the proposal to light the town by the electric light, stating that he was most particularly anxious to have it done. There were, he said, so many complaints against, and so much friction with, the gas company that it would be most desirable to have the scheme carried out. He could not promise that the electric light would be much cheaper than the present rate for gas, but it would be equally as cheap. What was necessary was to collect as many names as possible, both public and private, in order to find out the support they would have in the undertaking, and the number of persons who would avail themselves of the new light. He himself would take 100 lamps, and the Commissioners had something like 120 lamps at present under their control. He would enquire further, however, into the matter.

CORRESPONDENCE.

THE ORIGIN OF ELECTROLYTIC BLEACHING.

To the Editor of The Electrical Engineer.

SIR,—Mr. Watt, in his article on electrolytic bleaching (*Electrical Engineer*, Oct. 31, 1890, p. 380), has developed once more his theory that "electrolytic processes which had been abandoned by their inventors, solely owing to the cost of the current produced by batteries, have from time to time been reintroduced as absolute novelties," and he has given a few extracts from a patent obtained in 1851 by his brother, Charles Watt, to "show the close resemblance between this invention and many subsequent patents which have been based upon its essential details and claims." Cleverly-made extracts from a document sometimes supply arguments to demonstrate the reverse of what the document itself would have proved. Such is the case with Mr. Charles Watt's patent, which covers no less than four so-called inventions—*i.e.*, "the decomposition, by the agency of electricity, of saline or other substance in solution, placed in a vessel, divided into two or more parts or compartments by a partition or partitions composed of porous materials"; second, "a mode of preparing the metals of the alkalies and alkaline earths by the united action of electricity and heat"; third, "a mode of converting chlorides of potassium, of sodium, and of the metals of the alkaline earths into hypochlorites and chlorates by means of a succession of decompositions in the solution of the salt operated upon when induced by the agency of electricity"; and fourth, "a mode of separating metals from each other by the agency of a current or currents of electricity, and by means of vessels divided in two or more compartments separated from each other by porous partitions, such metals being at the same time freed from impurities."

Everyone who has studied the electrolytical production of hypochlorites will protest against the statement made by Mr. A. Watt, that the process patented by his brother in 1851, "now common property, may be adopted by anyone, it being perfectly practical."

It would be a pity if, on the eve of 1891, having made no progress, we were compelled to adopt a process which is not better now, with cheap electrical power, than it was in 1851 without it.

Charles Watt's electrolytic bleaching consists in decomposing a concentrated solution of chloride of sodium by means of the electric current, such solution being kept hot, by means of vessels divided into compartments separated from each other by porous partitions and in presence of carbon electrodes.

I am sorry to have to say that carbon electrodes cannot be used in an electrolytic tank when a bleaching liquor is prepared from a chloride solution. *Experte crede Roberto.* This I will explain in an article on the conditions of electrolytic bleaching.

Heat must be avoided. A concentrated solution means a considerable expenditure and an enormous loss of chloride of sodium.

The use of a diaphragm is still less economical, its great resistance debarring it from use on a practical scale, as it necessitates a larger consumption of coal to obtain from the chloride solution a given quantity of chlorine.

From every point of view, therefore, there is really nothing which may be of any service to the electrician of this age in the method exhumed by Mr. A. Watt, and the whole process must be rejected as worthless and impractical.

Mr. A. Watt is right when he points out that all that is necessary is to convert solutions of common salt or chloride of magnesium into bleaching liquor, but *hoc opus hic labor est.* It is not such an easy thing to do, and nobody yet has completely succeeded in this task. He is, however, wrong when he thinks that carbon electrodes, heat, a concentrated chloride solution, and a porous partition will allow the problem to be solved, and he is still more in the wrong when he speaks of regenerating *ad infinitum* the bleaching liquid.

I regret I cannot go into details and show to-day the delusion under which he is when speaking of regenerating chlorine from a solution after it has bleached paper pulp. Let us now see what right Charles Watt had to claim that he invented electrolytic bleaching—*i.e.*, the electrical production of hypochlorites.

In 1840, Th. Leikauf made experiments on bleaching by electricity, but they hardly deserve to be mentioned.

Mr. A. Watt says that all the electricians who tried to bleach have copied his brother's process; to this I reply that Charles Watt was not the first and true inventor of the electrolysis of chlorides, of the production of chlorates and hypochlorites, and of the electrolytic bleaching.

The precursors of Charles Watt are numerous, and the following quotations will show that there was nothing new in the so-called invention of Charles Watt "for converting chlorides into hypochlorites and chlorates by electricity, which first eliminates the chlorine at one electrode and the alkaline at the other electrode."

I find in Gruelin's "Handbook for Chemistry" (London, 1848), that a solution of common salt gives Cl at the + H gas and soda at the – pole. The salt is probably first resolved into chlorine and sodium, and the sodium is oxidised by the water, for when the cathode consists of mercury, sodium amalgam is produced." (Higgins and Draper, North Edinburgh *Philosophical Journal*, 14, p. 314.)

Is Mr. A. Watt ignorant that before Charles Watt patented his (?) invention for producing hypochlorites by electricity Brande had, in 1820 (see his "Manual of Chemistry," London, W. Parkes, 1848, T 1, p. 222), suggested the possibility of applying electrolytic hypochlorite of sodium to the art of calico printing, and showed that by bringing a small disc or figure of platinum rendered electro-positive upon a piece of coloured calico imbued with a solution of salt, and stretched over an electro-negative surface, white spots or patterns might be produced by the nascent chlorine, and that by reversing the electric state of the patterns the alkali evolved would produce variously coloured patterns upon grounds properly prepared.

A patent was taken by M. Bagg for a similar application, in which he proposed to produce various colours by the use of patterns formed of plates of various metals and alloys, acting upon different saline solutions.

It is exhilarating for the toilers who had to struggle against the many difficulties which electric bleaching presents to read the statement made by Mr. A. Watt, for the guidance of paper makers as to the advisability of adopting his brother's process.

Let every paper maker be his own bleacher in this manner; he will soon know what sort of client he has when after having adopted the system invented (?) and patented by Charles Watt in 1851, he ascertains that the 40 years' old process for bleaching costs him two or three times more than the use of bleaching powder.

I will not quote the many scientific papers printed before Charles Watt's patent on the electrolysis of salts and chlorides and its applications; I will merely refer the reader to the English patent granted to Cook in 1851 (No 13,620), before the letters patent to Charles Watt were sealed (No. 13,755), and also quote the French patent granted two years before to De Germini, 6th February,

1849 (No. 3,993), of which the text runs as follows: "I dissolve chloride of sodium in water, in the proportion of 50 grammes of sea salt for every litre of water, that is, 100 kilos for 2,000 litres; I then submit this saline solution to the action of a galvanic battery; the salt is decomposed into chlorine and sodium as fast as the metal is formed, its decomposing action on the water is added to that of the battery."

Soda is formed at the negative pole, while the chlorine combines both with the oxygen and hydrogen to form hydrochloric acid at the positive pole and hypochlorous acid, which combines with the soda, to form hypochlorite of sodium, which remains in solution, and which can be obtained in proportion to the duration of the passage of the current. The proportion of chloride of sodium I have given is more than sufficient to give the strength of the best *eau de javel*, yielding six chlorometric degrees, and can even be worked to 8deg. or 10deg. But instead of 50 grammes being dissolved per litre, 100, 200, or enough salt to saturate the solution can be used, and then by prolonging the action of the current until the salt is almost completely decomposed, a hypochlorite can be prepared which can be diluted to the required strength.

It is obvious that the number of cells in the battery, or the power of these cells, must be in proportion to the amount of product required in a certain time, or, *vice versâ*, in proportion to the time during which a given quantity of saline solution is to be transformed.

I will also point out that the action of the battery will be found to be in proportion to the amount of surface in contact with the solution to be decomposed.

The low cost of salt allows the bleaching hypochlorite, called *eau de javel*, to be produced very cheaply by this process, but it can be prepared still more economically by working in the same manner with the action of the battery on the chloride of sodium contained in sea water, or really on a solution containing less salt than the proportions I have indicated above.

"To facilitate and accelerate the formation of hypochlorite of soda, it is necessary to fix a shaft supplied with paddles between the two conductors in the liquor, so that the rotation imparted to it will keep the liquor continually agitated."

I think I have made clear that this, Charles Watt's, patent for bleaching no more resembles an invention than the part of it which refers to the separation of metals, and which Mr. Alexander Watt, who knows electro-metallurgy more than bleaching, carefully avoided to mention in his books on electro-deposition and on electro-metallurgy. I very much respect Mr. Alexander Watt's fraternal feelings, but they have carried him too far when he drops on the different electricians whose object is to realise progress in the application of electrolysis to a great industry.—Yours, etc., E. ANDREOLI.

62, Loughborough-park, S.W.

MR. ESSON AND INDUSTRIALISM.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I cannot allow the address of Mr. Esson to the Old Students' Association to pass without a protest. On page 437 of your last issue what he says about the improvidence of the working-man is a slander, and I, as a workman and very old student in every sense of the word, denounce those teachers who from their lofty position can find nothing too strong with which to whip the back of the British workman. Will Mr. Esson please tell us workmen, if we become good and abstain from beer and 'bacca, who is going to pay the revenue of 32 millions got from the same? When Mr. Esson goes into the social question he gets out of his depth. On page 438 he says, "It is not to the State that we owe useful inventions," etc.

Now, Mr. Esson, in times of peace men invent, but those same men could not invent if there was a continual war going on in their street. On the contrary, they would be thinking of fighting, but the Government of the country, with the aid of the army, etc., preserves peace. Hence, those inventors could not have invented had not the State taken them under its paternal wing. On page 439 Mr. Esson says: "The gospel of State socialism is mere rubbish." What, I ask, is the army, navy, and police, also post office, if not State socialism?

Trusting you will insert this, from an old student of Finsbury College,—Yours, etc., JAMES HUMPHRIES.

43, Clipstone-street, Fitzroy-square, W., November 15.

RULE FOR ELECTRIC BELL AND ALARM WIRING.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—Anyone who has read my rule thoroughly (see *Electrical Engineer*, November 7) will understand that it is applicable and useful, not only in simple electric bell installations, but also in fire and burglar-alarm wiring, gas lighting apparatus, electric clocks, telephones, etc. Mr. Koerber's rule (*vide* his letter last week) presumes that there is a push for every "red wire" to be connected to, and a bell for every "blue wire" to be connected to, and his distinction between "return" and "line" wires is not clear.

I congratulate him on the improvements and devices which he has originated in connection with bell fitting, but I fail to see what bearing they have upon the question in hand.—Yours, etc.,

W. PERREN MAYCOCK, A.M.Inst.E.E.

Croydon, November 19, 1890.

We have received a communication from Mr. Wm. Edwards contradicting Mr. Adam Koerber's statement that he was the first to introduce strip rubber for covering bell wires and tinned wire, and asserting that he, Mr. Edwards, taught the first-named improvement to Mr. Koerber, who bought his, Mr. Edwards's, father's business some 14 years ago—Mr. Edwards, sen., having succeeded Mr. Wm. Sherring, the originator of the improvement.

ELECTRICITY FOR MINES.

In the course of his presidential address to the Manchester Geological Society, delivered last week, Mr. John S. Burrows made some remarks on electricity as applied to coal mining.

A few years back, he said, great hopes were raised that portable electric lamps were so perfected as to be able to displace oil lamps, but he regretted to say that this expectation had not yet been fulfilled. The advantages of such a lamp were too obvious to need comment. The beautiful light hermetically sealed from contact with the surrounding atmosphere seemed the very thing required for their coal mines. There were two forms of this lamp, one with a secondary battery requiring to be charged from a dynamo, and the other with a primary battery, where the waste of the elements was replaced by refilling like an oil lamp. He had not been able to secure one of this latter type. Lamps of the former, or secondary battery type, in his opinion only required, to be a success, that the arrangements should be so altered as to prevent the charging solution (one part of strong sulphuric acid to nine parts of water) from getting to the metallic connections, and so destroying them. The charging was simple; a current strength of 7-10ths of an ampere at a potential of 10 volts for 10 hours, was all that was required, and he trusted the makers of the lamp would persevere till they had overcome what was the only drawback.

Without pretending to any gift of prophecy, he could conceive of a time when electricity would be carried throughout the workings of a colliery, both to give light and supply power. Though much must be done before electricity could be applied in this wholesale manner, enough had already been done to show that if certain difficulties could be overcome, such as sparking at the brushes, the use of electricity in coal mines was quite possible, and, he thought, economical. When necessity compelled its use wonderful progress would soon be made. Machinery for coal-cutting and drilling, driven by electricity, was in the market, though he had not seen any at work. Pumping by electricity was and had been an accomplished fact for some time in the Forest of Dean, Yorkshire, and elsewhere. A 40-h.p. electric locomotive weighing 5½ tons was now at work at an American colliery hauling tubs on a level underground, and the lighting was done by the same cables apparently with success. If, then, they could reduce the labour of the collier to supervision of his coal-cutting machines, spragging, and propping, and filling coal into tubs, all of which operations could be performed in the full current of air, they should have done a great deal towards making the higher temperature bearable. They had now working at Atherton Collieries a small experimental plant for winding coal tubs up a downbrow, the motive power being electricity. This arrangement worked continuously, and

had never failed except when the breakdown could be clearly traced to some defect in construction of the generator or the service; in fact, with first-rate appliances there seemed no reason to fear a breakdown, any more than with a steam engine, and if they kept a spare armature in reserve, the faulty armature of either machine could be replaced in 30 or 40 minutes. In putting up a large electromotive plant the first cost would probably be less than for a similarly powerful plant for compressed air, assuming the steam engines to be the same, the generator belts and countershaft would not cost as much as the air-compressing cylinders and receivers. The air pipes, bearers, and cost of fixing the pipes would well cover the cost of the cables. The motor and shafting underground would cost no more than the air engines, and the drum or other hauling gear would be the same in both cases. Against all this there was one great drawback—namely, sparking at the brushes; in a main road this would not, perhaps, matter much, but it would prevent the application of electricity as a motive power in the workings, unless some means were found to obviate this danger. In conclusion, it seemed to him that very little progress had been made in the 600 years of coal mining, especially in the lighting of mines, and in appliances for saving manual labour, but in time electricity would revolutionise both their defective means of lighting and their old-fashioned plan of getting coal by hand labour. He knew that coal-cutting machines had been tried from time to time during the past 30 years, but (apart from any imperfections in the machines themselves, the hitherto abundant supply of labour, and the great cost of air-compressing plant) he believed that the difficulty of maintaining rigid iron pipes in mines where the floor lifted, and where the roof fell or had to be taken down, had deterred many from giving machinery a trial. The laying and maintenance of flexible electric cables would be a much simpler matter, and they could easily be removed when desired. Certainly electricity was yet in its infancy, but it was a promising infant and was likely to develop into a giant some day. Let him, then, earnestly recommend their younger members to avail themselves of the many opportunities of acquiring some knowledge of electrical science before the responsibility and work inseparable from the management of large concerns left them no leisure and often less inclination to take up more brain work. To their older members he ventured to suggest that it was worth while encouraging, as far as might be, the efforts of those who were seeking to provide them with a servant so powerful and efficient as electricity.

WILLANS-KAPP.

The accompanying illustration shows a Willans engine and a Kapp dynamo, built by Messrs. Johnson and Phillips, on the same bed-plate. Both engine and dynamo are too well known to need detailed explanation. The table below shows the economy and efficiency of the combination, and speaks very highly for the productions of these makers.

Willans-Kapp Combined Engine and Dynamo.

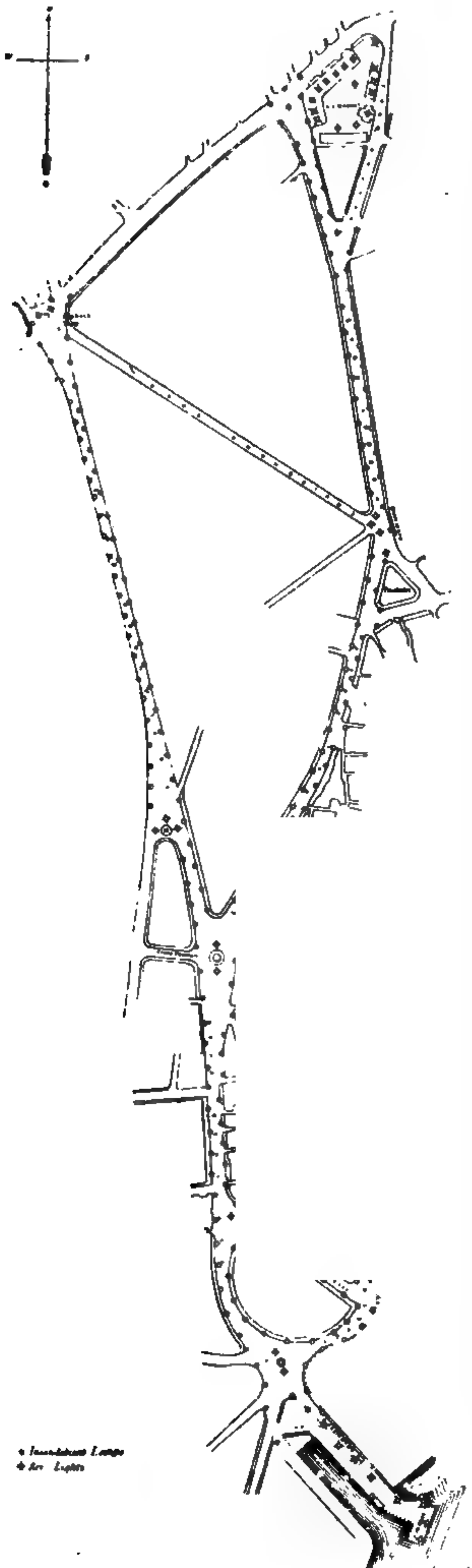
Consumption Trial, No. 982, for Birmingham P.O.

Engine No. 982. Barometer 30·3 falling. Dynamo No. 83.
Date, August 8, 1890. Present, Mr. Low.

Water collected. Weight in lbs.	Time. hrs.	min	sec.	100lb. Interval. min	sec.	Amperes	Volts	Remarks.
4,420	3	36	15			450	112	
4,520	3	39	34	3	19	452	112	Voltmeter, Evershed 436, checked by small Siemens' dynamometer.
4,620	3	43	53	3	19	440	112	
4,720	3	46	13	3	20	448	112	
4,820	3	49	34	3	21	454	112	
						440	112	
5,020	3	56	11	3	$18\cdot5_3$	443	112	Ammeter, Siemens =2477.
5,120	3	59	34	3	22	450	112	
5,220	4	2	50	3	16	452	112	
						448	112	
5,420	4	9	31	3	$20\cdot5_2$	450	112	
5,520	4	13	46	3	15	456	112	
						450	112	
5,720	4	19	20	3	$17\cdot0_1$	452	112	
						438	112	
5,920	4	26	9	3	$39\cdot5_2$	438	112	
6,020						440	112	
6,120	4	32	49	3	$20\cdot0_3$	450	112	
1,700	0	56	34		Mean	447·2	112	Kilowatts 50·2

Indicated H.P.=79·7. Electrical H.P.=67·4. Commercial efficiency=84·6 per cent. Total water per hour, including escape from jet cocks, 1,807lb. 27lb. of steam per E.H.P. hour.

PLAN OF BOMBAY LIGHTING.



[For specification see p. 432 of our last issue.]

PHYSICAL SOCIETY.—Nov. 14, 1890.

Prof. W. E. Ayrton, F.R.S., President, in the chair.

The following communications were made:

"On Certain Relations Existing Amongst the Refractive Indices of the Chemical Elements," by the **Rev. T. Pelham Dale, M.A.** The first part of the paper corroborates the results announced in a communication made in May, 1889, on the same subject, and says that as far as experimental data are forthcoming the refraction, $\mu-1$, divided by the vapour density, d, is equal to a constant multiplied by some integer. Several metals, whose refractions have since been determined, conform to this law. On examining the relation between molecular weight, M, and refraction, similar conclusions are arrived at, for to a fair degree of approximation the ratio, $M/\mu-1$, is a constant or a simple multiple of this constant. The question as to how far the relation, $\mu-1/d=C$, holds good for the same element in the three states of vapour, liquid, and solid, has been examined as far as data exist for this purpose. The resulting numbers are not identical, but some of the data themselves are doubtful. Another relation is between the molecular distances, h (see *Proc.* Physical Society, vol. ix., p. 167) and the atomic weight, a, of the elements, h being nearly proportional to $\sqrt{a}$. In the case of selenium, sulphur, and phosphorus, the agreement is close, but for bromine, chlorine, and carbon, not so good. A fifth relation appears to exist between the upper limit of refraction and the line spectra of elements. For example, the upper limit of refraction for selenium occurs at wave-length 5295·7, whilst its spectrum exhibits a remarkable series of strong lines about this wave-length. A similar relation apparently holds with sulphur, phosphorus, and bromine. Gold also shows a series of strong lines about C, in the vicinity of which the metal has the greatest reflective power. The author finds that selenium polarises and reflects nearly all the light that falls on it at a large angle, and suggests that it may be used in polariscopes. He has also endeavoured to connect together the phenomena of a limit of refraction and anomalous dispersion. In the case of Fuchsin the dark space coincides with the limit of refraction, and the same is probably true of cyanin. If one of the anomalous indices be given the other can be found. He also believes that bodies of high molecular weight give anomalous dispersion, and thinks solutions of iodine will exhibit the phenomenon. The mathematical investigation of the whole subject involved difficulties arising from the want of reliable data, and the author hopes that some member will take up the necessary experimental determinations.

Dr. Gladstone thought the author underestimated the amount of work done and in progress on the subject, for the question whether $\mu-1/d$ is constant or not is so being investigated by many. The French physicists, he said, had found the quantity nearly constant, but Lorenz's expression, μ^2-1/μ^2+2, is slightly better when applied to compounds in the liquid and gaseous states. Metals were difficult to deal with, especially as, according to the recent paper of Du Bois and Reubens, their refractions do not follow the law of sines.

Mr. Dale here suggested that they might be related to hyperbolic sines.

Dr. Gladstone, continuing, said that by taking solutions of metals, it was found that their specific refractive energies were nearly inversely as the square of their combining weights, but at present the known cases were not sufficient to establish a law.

Prof. Rucker said that of the two expressions, $\mu-1/d$ and μ^2-1/μ^2+2, the latter seemed preferable, for it could be converted into electrical quantities by writing K for μ^2. The expression then becomes $K-1/K+2$, and if this can be shown to be constant by electrical work this would be an argument in its favour. On the subject of anomalous dispersion he directed Mr. Dale's attention to Mr. Glazebrook's report on optical theory made to the British Association.

Mr. Dale, in reply, pointed out that from the nature of the two formulæ any inaccuracy or variation in μ would affect theirs more than Lorenz's. He also thought that $\mu-1/d$ was a limit towards which the numbers tend.

"Tables of Spherical Harmonics, with Examples of their Practical Use." By **Prof. J. Perry, F.R.S.** The author defined a spherical harmonic as a homogeneous function of x, y, z satisfying the equation $\frac{d^2V}{dx^2}+\frac{d^2V}{dy^2}+\frac{d^2V}{dz^2}=0$, stated the fundamental properties of such functions, and pointed out their importance in problems on heat, electricity, and hydrodynamics. Referring to zonal harmonics (homogeneous functions of $(x^2+y^2)^{\frac{1}{2}}$ and z), he showed that these harmonics are symmetrical with respect to the axis of z, and might be expressed as functions of the angle, θ, which the line joining the point, x, y, z, to the origin makes with the axis of z, multiplied by r^i, where r is the radius vector and i the degree of the homogeneous function. These functions of θ are called zonal surface harmonics, and are designated by P_0, P_1, P_2, etc. P_i according to the degree of the function, and it was the values of these quantities which form the tables brought before the society. The tables comprise the values of P_1 to P_6, and are calculated to four places of decimals and for every 1deg. between 0deg. and 90deg. As an example of such tables, the case of a spherical surface covered with attracting matter whose density varied as the square of its distance from a diametral plane, was taken. It was required to find the potential both outside and inside the sphere, and to determine the equipotential surfaces and lines of force. The potentials inside, A, and outside, B, were shown to be given by

$$\frac{A}{\pi}=8+\frac{16}{5}r^2P_2 \text{ and } \frac{B}{\pi}=\frac{8}{r}+\frac{16}{5}\frac{1}{r^3}P_2$$

respectively. By giving A and B definite values and choosing values of r, the corresponding P_2's can be calculated, and the value of θ determined from the tables. Hence any equipotential surface can be easily determined, and lines drawn to cut these surfaces orthoganally are lines of force. Another problem, which had been tried, consisted in finding the directions of the lines of force near a circular coil of rectangular cross-section when an electric current circulates in the coil. This was treated approximately by first calculating the potential at six points along the axis in the neighbourhood of the coil and then finding, by Gauss's method, the coefficients A_0, A_1, A_2, etc., of an expression in ascending powers of z which agreed with the calculated potentials at the points chosen. The formula

$$V = A_0 + A_1 r P_1 + A_2 r^2 P_2 t, \text{ etc.},$$

or its corresponding expression in inverse powers of r, was then assumed to give the potential at any point in the space considered. By giving V definite values, a series of equipotential surfaces were determined and the lines of force drawn. On putting the calculations to the test of experiment, the approximate solution of this very difficult problem was found to be very nearly correct.

THE LIGHTING OF STROUD.

A public meeting called by Messrs. V. A. Lawson and E. N. Witchell was held last week at Stroud (Gloucestershire) to consider the question of electric lighting for the town. It was well attended by members of the Local Authority, manufacturers, and tradesmen.

Mr. A. Apperly having been voted to the chair,

Mr. N. Witchell opened the meeting by saying that they had met to discuss the advisability of supplying the electric light and motive power by means of electricity to the town and district of Stroud. During the last two or three years much progress had been made in the matter of electric lighting, and he believed that 25 towns in this country now had this light, including Liverpool, Manchester, Blackpool, Birmingham, Bath, Bournemouth, Brighton, Eastbourne, Taunton, and, in Gloucestershire, the insignificant town of Wickwar. Fifty-seven other towns had applied for provisional orders, and in 21 of them the work of installation had commenced.

Mr. Lawson said the details of this proposed electric supply scheme might be divided into three sections. The first was the smallest or minimum supply at the least possible cost. This included the erection of a central station and the installation of complete set of plant of sufficient power to supply 1,500 10-c.p. lamps at one time, which would permit of 2,500 10-c.p. lamps being installed, inasmuch as the whole of the lights were never in use at one time. The length of mains required for this scheme would be about 1½ miles, and would include the principal streets in the town within half-mile radius. The capital required would be about £10,000, and from this system either arc lights or incandescent lamps could be supplied as required. The second consisted of a similar plant, but of sufficient capacity to supply 2,500 10-c.p. lamps, or their equivalent, at once, and permitting an installation of 4,000 10-c.p. lamps; the buildings, however, and accessory plant, and also mains, would be of sufficient size for two plants in full work, and arranged so that the station and plant could be extended at any time at small expense when the extension of lighting necessitated. The capital required for this would be about £15,000, including three miles of mains, with junction and service boxes complete; this would supply the principal portion of the town within one mile radius. When the load became nearly full on either the first or second scheme, a second plant, could be added; in the first case at the cost of about £3,500, and in the second case about £4,500, which would nearly double the lighting power. Then when the load reached about half the capacity of the second set of plant a third could be added and extended as might be found necessary. This would be the most economical manner in which the business could be built up, and would enable a company to start in Stroud with a capital of £15,000, which would be sufficient to commence with; and, upon this capital, assuming that 2,000 lights of 10 c.p. each, could be obtained amongst the mills, factories, shops, and private houses, it was estimated that a revenue could be earned sufficient to pay a dividend of 9 per cent., and this was a fair sample of the dividends which might be anticipated on greater extension, as although spare plant was not provided for in the present estimate, there was a considerable sum for mains and buildings over what was required for the present proposed single plant. It was proposed that the current should be sold by meter at the average rate of 8d. per Board of Trade unit, which was equal to ¼d. per hour for a 10-candle lamp. This would enable them to calculate what it would cost consumers as compared with other methods of lighting, and, although probably costing a little more, there were advantages in the shape of there being no unhealthy fumes or smell, and greater cleanliness, which, he believed, in towns and places where the light was already adopted, more than compensated for the extra outlay per annum. For instance, paint, ceilings, furniture, decorations, etc., were saved from discolouration and tarnish, and in shops and places of business where perishable goods are stocked a great saving is effected, which in the case of some drapers' shops in London, he was told, was as much as 5 per cent. The cost of installation in shops would be from 15s. to £1 per light, and in private houses from £1 to 30s. per light, depending of course upon the class of fittings. This was the actual cost of wiring and fitting the house. Then the rent of a meter would be about the same as a gas-meter. The third scheme included the supply of motive power, for instance, to sewing machines in the clothing trade, in which a vast amount of labour was employed. And also, perhaps, at some future time the current could be utilised for charging storage cells for tramways. If this scheme should be entertained the House-to-House Electric Supply Company, Limited, would take 25 per cent. of the cost in shares; they had already applied to the Board of Trade for a provisional order.

The **Chairman** said the scheme did not extend far enough to take in many mills, and without them the cost would be far too large for a town like Stroud.

Mr. Lawson said that with additional capital they could extend the mains any distance, but if one mill wanted a supply outside their prescribed radius they would not be able to give it unless there were other customers *en route*. If they started with a capital of £10,000 they could increase it at any time.

In reply to other questions, **Mr. Addenbrook** explained the nature of the high-pressure transformer system (2,000 volts) which would be used.

Mr. Apperly said he had used the light in his house between two and three years, and he had had no breakdown. Lamps which were expected to run a thousand hours had run considerably over that time; only five had given up, and those he thought were damaged at starting. They were Edison-Swans. He had a gas engine and accumulators, enough for 40 lights for nine hours, and 16 and 8 c.p. lamps. A great advantage was that the ceilings, picture rods, etc., were as clean to-day as when they were put up. The light cost him about £20 a year, while he used to pay £24 or £25 for gas. The whole cost he reckoned was about equal to gas. He was putting in a little installation at the mill for 80 lights.

Mr. C. Ritchie, who has the light installed in his mill, said that his experience of four years showed him that the light could only be made profitable in a mill where the manufacturer had an excess of engine power, as he had. He had a more powerful engine than was required for the machinery, and a result of using the surplus power for the light was that the engine went steadier and better, while the increase in the consumption of coal was scarcely to be reckoned. Reckoning the expenses connected with the installation and depreciation, about £15 per annum, he thought the cost was as nearly as possible the same as gas. He was not reckoning motive power, which would make it more. The advantage was that during the dark hours, from four to six, he got more work done in several departments than before, in spinning (especially dark colours), weaving, burling, and mending, and had so been able to reduce the staff in some departments. That might be taken as a set-off against the cost. If he had to put in an engine specially he should consider the light more of a luxury than a necessity.

Mr. Addenbrook said a depreciation of 15 per cent. was outrageous.

Mr. P. J. Evans remarked that if the factory hands worked after hours the case would be different. At the present gas was only used about 300 hours in the year. If the mills were running all night, as in some industries in the North, electric light might be worth having, but he had concluded that it would not pay in their factories. He should be delighted to have it if it cost about the same as gas, but he had not been able to ascertain that it did. At their mill they spent about £140 a year in gas. They would want about 600 electric lamps, and he had found that the cost would be something like £600. Would it pay to put in a plant for the town?

Sir Wm. Marling thought manufacturers would have the light if it cost not more than 25 per cent. more than gas.

Mr. Addenbrook said that for general purposes the light could be supplied for 25 per cent. above the cost of gas, but if several factories had to be supplied it would be difficult to do it at that cost, because so much light would be needed at once. The case was different in shops, where the use averaged three hours a day all the year round, or private houses, where the light was turned low upstairs and high downstairs and *vice versâ*. It seemed to come to this, whether Stroud town could be supplied. As the demand grew, and the cost became smaller, it would then be practicable to supply factories at the same rate. Would the meeting give its attention to the desirability of lighting the town?

The following resolution was carried unanimously: "That this meeting approves of the proposal to light Stroud and district by means of electricity, and recommends that a committee be appointed to go into the matter and consider the best course to further the scheme."

The meeting did not separate before they had had a smack at the gas company, the gas supplied being stated to be very bad. One of those present made the very significant remark that the light in the meeting-room was better than they had had for weeks. The company were putting on extra pressure under pressure.

LEGAL INTELLIGENCE.

ACTION BY ELECTRICAL ENGINEERS.—SIEMENS v. FALERO.

The following case came before his Honour Judge Bayley in the Westminster County Court on Tuesday.

The plaintiffs are well known, and the defendant is an electrical engineer residing at 100, Fellowes-road, Hampstead. The action was brought to recover the sum of £4. 17s. 6d. for work done in cleaning and testing a dynamo in accordance with the defendant's instructions. It appeared from the opening of counsel, that in the early part of this year the defendant wrote to the plaintiffs giving them certain instructions as to the work. On March 18 the plain-

tiffs sent to defendant's house for the dynamo, but their man was unable to get it away, and it was sent for again on the following day, and in due course the work was completed, and it was returned to the defendant. No complaint was ever made by the defendant until some weeks afterwards when payment was asked for, when, for the first time, he complained that the work was not properly done, and that he had been exorbitantly charged for it. Considerable correspondence then took place between the parties, but the plaintiffs refused to accept a lesser sum for their work, as they considered they had only charged what was fair. The defendant refused to pay the account, and consequently the present action was brought.

Mr. Thomas Nutall was called, and said he was in the employ of the plaintiff firm, and the work in question was executed under his supervision. In his opinion, the charges made were those ordinarily charged in the trade, and were very reasonable. The work which was required to be done to this dynamo was of a very technical character, and required considerable skill, especially in the operation of testing. The dynamo had been lying by and got rusty, thus entailing greater labour.

Robert Ayres, another workman in the plaintiffs' employ, gave evidence as to the work having been in every way thoroughly done, as did also a **Mr. Ruscoe**, through whose hands the machine was passed for the purpose of testing.

For the defence, **Mr. Louis Falero** was called and said he purchased the machine from the plaintiffs' house in Paris, but shortly afterwards he had occasion to come to England, and he left it carefully oiled and packed in the hands of a friend of his at Paris. Finding that he was going to remain in London, he had the dynamo sent over, and then it was that he instructed the plaintiffs' to clean and test it. Up to that time it was quite new, and had never been used, therefore he contended that the plaintiffs' charges for what they had done were very excessive. He believed it was a custom in the trade, that when a dynamo was purchased from a firm they undertook to clean and look after it free of charge for a certain time. He did not expect that the plaintiffs in this case would have charged him anything, much less that they would have charged him so large a sum. He considered that the sum of £1, which he had paid into court, was quite sufficient payment, especially when it was taken into consideration that the work of cleaning was done so badly that he had to do it over again himself. He could have done the whole of the work himself in one hour had he felt disposed, but he thought it was better to send the machine to the makers.

On giving judgment, his **Honour** said there was ample evidence on the plaintiffs' side to show that the charges were fair and reasonable. There was, however, an item of 4s. charged in the account for carriage of the dynamo, which sum must be disallowed, but with regard to all the other portions of the claim, judgment would be for the plaintiffs with costs.

COMPANIES' MEETINGS.

EASTERN EXTENSION TELEGRAPH COMPANY.

At an extraordinary general meeting at the offices, Winchester House, E.C., on Wednesday, Sir John Pender presiding, the resolution passed at the meeting on the 22nd ult.—for authorising the issue of mortgage debenture stock to an amount not exceeding one-third of the share capital of the Company for the time being issued and paid up—was unanimously confirmed on the motion of the **Chairman**, seconded by the **Marquis of Tweeddale**.

The **Chairman** stated that the object of the resolution was to enable the Directors to replace the £320,000 of 6 per cent. debentures by an issue of 4 per cent. debenture stock—a measure which would save the Company about £6,000 a year.

In answer to Mr. J. Lewis, the **Chairman** stated, with reference to the subscriptions for the new mortgage debenture stock, that they proposed to take 5 per cent. on application, 5 per cent. on allotment, and 90 per cent. on the 15th of January. The 1st of February was the day on which they would be obliged to have the money ready to redeem the 6 per cent. bonds.

COMPANIES' REPORTS.

SWAN UNITED ELECTRIC LIGHT COMPANY.

Directors: J. S. Forbes, Esq. (chairman), F. R. Leyland, Esq. (deputy chairman), E. W. Batt, Esq., W. C. Quilter, Esq., M.P., and J. W. Swan, Esq.

Eighth annual report of the Directors, to be presented at the ordinary general meeting of the Company, to be held at the Cannon-street Hotel, London, on Tuesday, 25th November, 1890, at 12 noon.

The accounts, which are herewith presented to the shareholders, are for the year ending 30th September, 1890. After paying all current charges, and making due allowance for depreciation, there is a credit balance of £44,477. 15s. 10d. The Directors recommend that out of this balance a dividend of 10 per cent. for the year be declared; an interim dividend at the rate of 6 per cent. per annum, amounting to £11,104. 0s. 5d., has already been paid in respect to the first half of the year; the balance of the 10 per cent. for the entire year to be distributed in accordance with clause 77 of the articles of association, and to be payable on the 1st December next. This will absorb £24,921. 17s. 7d., and leave £8,451. 17s. 10d. to be carried forward. The decision in the patent suit in Germany was given in favour of this Company in the Court of Appeal in Berlin during the summer. The Allgemeine Electricitäts Gesellschaft have appealed from that decision to the Supreme Court at Leipsic. It is expected that the case will be heard and finally decided before Christmas. The Compagnie Générale des Lampes Incandescentes in Paris have not yet been able to obtain a decision in the courts on the validity of their French patents, but they think that the case will be reached and a decision given during next spring. Their business is increasing, but the competition which they have to sustain compels them to sell lamps at a lower price than heretofore. The Directors who retire by rotation are F. R. Leyland, Esq., and W. C. Quilter, Esq., M.P., who, being eligible, will offer themselves for re-election. Messrs. Welton, Jones, and Co., the auditors, will also retire, and will offer themselves for re-election.

BALANCE-SHEET, 30TH SEPTEMBER, 1890.

Dr.	£	s.	d.	£	s.	d.
To share capital—						
19,750 shares of £5 each fully paid	98,750	0	0			
78,949 shares of £5 each, £3. 10s. paid	276,321	10	0			
				375,071	10	0
,, Forfeited shares				3,530	0	0
,, Sundry creditors				3,477	9	7
,, Balance from previous account	31,094	17	0			
Less dividend paid 20th Nov., 1889	22,208	0	9			
	8,886	16	3			
,, Balance 30th September, 1890...	35,590	19	7			
	44,477	15	10			
Less interim dividend at the rate of 6 per cent. per annum for six months ended 31st March, 1890, paid on May 21st, 1890	11,104	0	5			
				33,373	15	5
				£415,452	15	0

Cr.	£	s.	d.	£	s.	d.
By cost of patent rights, etc., represented by shares in Edison and Swan United Electric Light Company, Limited, with £208,478 paid; shares in La Compagnie Générale des Lampes Incandescentes with £30,489. 8s. 3d. paid; patents held by the Company for Germany, etc., as per last balance-sheet	330,334	11	3			
,, Additional expenditure thereon	597	7	2			
	330,931	18	5			
Less amount realised for sale of plant, etc.	94	16	0			
				330,837	2	5
,, Outlay on factories, plant, etc., as per last account	2,453	16	7			
Less depreciation	490	15	4			
				1,963	1	3
,, Sundry debtors				26,733	1	10
,, Stock on hand				11,124	14	0
,, Investment in Prussian consols. Cost				5,120	0	0
,, Investment in new $2\frac{3}{4}$ % consolidated stock. Cost				29,004	19	6
,, Cash on deposit and in hand				10,669	16	0
				£415,452	15	0

PROFIT AND LOSS ACCOUNT FOR YEAR ENDING 30TH SEPTEMBER, 1890.

Dr.	£	s.	d.
To stock, October 1st, 1889	3,770	8	6
,, Purchases	9,115	16	8
,, Office expenses, Directors' fees, rent, salaries, income tax, etc.	3,513	0	8
,, Wages and expenses at factory	5,046	15	8
,, Depreciation	490	15	4
,, Sales ledger reserve	150	0	0
,, Balance	35,590	19	7
	£57,677	16	5

Cr.	£	s.	d.
By sales, less commissions and allowances	12,347	13	9
,, Transfer fees and interest	1,768	13	0
,, Dividend on shares in La Compagnie Générale des Lampes Incandescentes, less tax	1,771	2	0
,, Dividends on shares in the Edison and Swan United Electric Light Company, Limited	30,665	13	8
,, Stock, September 30th, 1890	11,124	14	0
	£57,677	16	5

BLACKPOOL ELECTRIC TRAMWAY COMPANY.

In their report the Directors say that the revenue account shows a balance in hand for the year of £2,455. 9s. 3d. Adding to this £231. 5s. 10½d. from last year, makes an available amount of £2,686. 15s. 1½d., of which the Directors recommend the following disposal: Dividend of 7½ per cent. on the called up share capital,

free of tax, £1,501. 17s. 6d.; depreciation and reserve fund, £1,000; balance to next year's account, £184. 17s. 7½d. The depreciation and reserve fund, with the addition of £1,000 as above recommended, will be £4,418. 15s. 1d. The number of passengers carried this year was 812,299. The number of miles run during the year was about 92,000. The retiring Directors are Messrs. Ormerod, Shaw, and Smith, who are eligible for re-election. Mr. Broadbent's services as managing director have been secured again for the coming year. The receipts show that passenger receipts from cars during 1890 have been £6,281, as compared with £6,328 during 1889, the total receipts from all sources being £6,490 as against £6,547 last year. The principal items of expenditure during 1890, with the corresponding figures for last year in parenthesis, are as follows: Repairing centre channel, £126 (£254); electrical fittings, £170 (£192); wheels for cars and sundry ironwork, £147; Corporation of Blackpool for labour and materials, £112 (£94); wages of drivers, conductors, etc., £1,177 (£1,132); coal, coke, oil, etc., £280 (£240); district, borough, and poor rates, etc., £444 (£191); year's rent of line, £723; salary of managing director, secretary, and auditor, £240 (£190); the total expenditure during 1890 being £4,035, against £3,620 in 1889.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the past week amounted to £5,249.

Electric Construction Corporation.—The Directors have declared a dividend of 6 per cent. per annum on the ordinary shares for the past year.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting the "fifth" payable to the London Platino-Brazilian Company, were £4,087.

West India and Panama Telegraph Company.—The estimated traffic receipts for the half-month ended November 15 were £2,571, as compared with £2,878 in the corresponding period of 1889. The July receipts, estimated at £5,550, realised £5,560.

Business Notice.—We are informed that the business hitherto carried on by Messrs. Sydney F. Walker and Co., at 92, Quayside, and by R. H. Barnett and Co., at Elswick Court, Newcastle-on-Tyne, will in future be carried on by Messrs. R. H. Barnett and A. S. Barnard, at 92, Quayside, Newcastle-on-Tyne, as Barnett, Barnard and Co., electrical and general engineers and contractors.

Elmore's Foreign and Colonial Copper Company.—A circular has been sent out to the holders of priority and founders' share by the Secretary of the Company stating that after subscribing for the £50,000 debenture stock in the French company there will remain a sufficient amount to pay a cash dividend of £5 per priority share, and the Directors now declare an interim dividend of £4 per share, payable on the 8th of December next. The Directors will propose to the annual general meeting, which will be held in January, a further dividend from the cash receivable, and from the realisation of the shares and debenture stock of the French and Austro-Hungarian companies. Dividend warrants will be sent in due course. The Directors have received a suggestion from several holders of priority and founders' shares, which has been approved of by shareholders holding over half the capital of the Company, that instead of waiting to realise the securities held by the Company to pay the second £5 dividend on the priority shares, a trust company should be formed, to whom the securities received by this Company from the French and Austro-Hungarian companies should be sold. By this means the Directors would be in receipt of further cash and shares for distribution amongst the holders of the priority and founders' shares.

PROVISIONAL PATENTS, 1890.

NOVEMBER 10.

18076. **Improvements in sockets or holders for incandescent lamps.** James Yate Johnson, 47, Lincoln's-inn-fields, London. (James Walter Collier, United States.) (Complete specification.)

18088. **Apparatus to be employed at telephonic switchboards.** John Edward Kingsbury, 24, Southampton-buildings, London. (The Western Electric Company, United States.)

18096. **Improvements in galvanic elements.** Victor Baron von Alten, 28, Southampton-buildings, London.

NOVEMBER 11.

18103. **Improvements in electric switches.** Charles Edward Knowles, 70, Market-street, Manchester.

18158. **An improved electric pressure indicator.** Charles Hodgkinson Gray, 24, Birchin-lane, London.

8163. **An appliance for the administration of electricity to the human body in Turkish baths.** Moses Humm, Leslie House, Westbourne-road, Forest Hill.

8180. **Improvements in primary batteries, and in apparatus connected therewith.** Sir Charles Stewart Forbes, Bart., 21, Finsbury-pavement, London.

8186. **Improvements in electrical measuring instruments.** Henry Harris Lake, 45, Southampton-buildings, London. (Edward Weston, United States.) (Complete specification.)

18190. **Improvements in multiplex telegraphy.** Charles Adolph Gisborne, 77, Chancery-lane, London. (David Herbert Keeley, Canada.) (Complete specification.)

18195. **Improvements in telephonic apparatus for minimising or overcoming inductive and other undesired electrical disturbances in telephonic circuits.** Arthur Edgar Cotterell, Brooklyn Church-road, Moseley, near Birmingham.

NOVEMBER 12.

18206. **Improved commutator for dynamo-electric generators and motors.** Henry Davis and Arthur Henry Stokes, 52, Chancery-lane, London.

18217. **Improved protector for telegraph, telephone, and other electric instruments.** Daniel Maclean, Woodville, Burghill-road, Sydenham.

1 220. **Improvements in connecting electric lamps and apparatus to leads.** William Allen and Orlando Venning Thomas, 15, King-square, Bristol.

18247. **Improvements in fittings for electric lamps and their conductors.** Joseph Devonport Finney Andews, 28, Southampton-buildings, London. (Complete specification.)

18248. **Improvements in electrolysis.** Jonathan Aldous Mays, 20, Daleham-gardens, London.

NOVEMBER 13.

18266. **Improvements in electric tramways and electric conduits.** Henry John Davies and Lewis Benjamin Saltwell Dutson, 14, Vicarage-place, Walsall, Staffordshire. (Complete specification.)

18270. **Improvements in electrical conduits and conductors.** John Macintosh Mackay Munro, 154, St. Vincent-street, Glasgow.

18292. **Improvements in switches for electrical purposes.** Bernard Mervyn Drake and John Marshall Gorham, 66, Victoria-street, Westminster. (Complete specification.)

NOVEMBER 14.

18339. **An improved process and apparatus for the production of oxygen and hydrogen by electrolysis.** William Robert Lake, 45, Southampton-buildings, London. (Alaricus Dehuard, France.)

NOVEMBER 15.

18409. **The improvement of electrical switches and other electrical apparatus.** Luis Alwyn Davies, 9, Scarsdale-terrace, Kensington, London.

18412. **Improvements in electric batteries and lighters for cigars and other purposes.** David Robertson, 96, Buchanan-street, Glasgow. (Complete specification.)

18470. **Improvements in telegraph keys.** Arthur Foster Purdy, 151, Strand, London. (Date applied for under Patents Act, 1883, Sec. 103, 15th April, 1890, being date of application in United States.) (Complete specification.)

SPECIFICATIONS PUBLISHED.

1884.

14233. **Induction coils.** J. and E. Hopkinson. (Amended specification.) 8d.

1889.

17142. **Electromagnetic transformers.** Bollman. 6d.

19199. **Electric batteries.** Badcock and others. 6d.

19525. **Electricity meters.** Scott and others. 8d.

19831. **Electric switches.** Dorman and Smith. 8d.

19951. **Electrical switches.** Bayley. 8d.

20856. **Voltaic batteries.** Fitzgerald and Hough. 6d.

1890.

232. **Electric motors, etc.** Hopkinson and others. 8d.

3082. **Incandescent electric lamps.** Langhans. 4d.

6032. **Electric heating apparatus.** Dewey. 8d.

6037. **Electric railway vehicles.** Dewey. 8d.

8242. **Electric welding.** Lake (Lemp). 6d.

12830. **Secondary batteries.** Lake (Johnson and another). 8d.

13421. **Welding metals electrically.** Thompson (Coffin). 8d.

13751. **Electric switches.** Huntington. 6d.

13790. **Electric conductors.** Lake (Curtis). 11d.

14186. **Electric switches.** Perkins. 8d.

14191. **Electric railways.** Dewey. 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2½
Swan United	3½	5½
Crompton & Co., Pref.	—	5½
National Telephone	5	5¼
Electric Construction	10	8

NOTES.

Cellulose insulation for telegraph wires is being tried in Hungary by the telegraphic administration.

Paris.—The Municipal Council has passed a resolution n favour of lighting the Avenue de la République electrically.

Southport's compulsory area will be comprised by Eastbank-street and Lord-street, between Corporation-walk and Nevill-street.

National (U.S.) Electric Light Association.—The next meeting will be held at Providence, Rhode Island, on February 17, 18, and 19.

Acton.—The Local Board name the following streets as the compulsory area under their order—viz., High-street, Churchfield-road, Market-place, and Church-road.

Hertford.—The Corporation will apply for an order. The steam laundry which was opened here last year has been lighted electrically and with satisfactory results.

Old Students' Association.—To-night (Friday) there is a smoking concert at the Mason's Hall Tavern, Basinghall-street, E.C. The programme is a good one.

Liverpool.—The Liverpool Electric Light Company are promoting a Bill to extend their area of supply over the greater part of the city, both to the north and south.

King's College, London.—The council are ready to receive applications for the appointment of demonstrator in electrical engineering. Particulars can be had of the secretary.

Paris Meter Competition.—The Municipal Council of Paris have nominated MM. Mascart, Potier, Hospitalier, Cochin, and Lyon-Allemand on the jury in connection with this competition.

China.—It is stated that the Chinese Government has consented to the long-projected construction of a telegraph line between Pekin and Kiachta, on the frontier between Siberia and China.

Prof. Tyndall.—Our readers will regret to hear that Prof. Tyndall, who has been staying at Hind Head House, Haslemere, since his return from Switzerland, is unwell and confined to his house.

Book Received.—A copy of the fifth edition of Mr. A. Bromley-Holmes's little book on "The Electric Light" has reached us from the publishers, Messrs. Bemrose and Sons, 23, Old Bailey, E.C.

Underground Railway Extension.—The City and South London Railway Company are promoting a Bill to give them powers to extend their line from the King William-street Terminus to Islington.

City and South London.—Apparently this has already caught on with the public, for we notice an enterprising lodging-house keeper advertises a "comfortable home" at Clapham "near electric rail."

Royal Society.—At the meeting last Thursday afternoon, Messrs. G. J. Burch and V. H. Veley were to read a paper on "The Variations of E.M.F. of Cells consisting of Certain Metals, Platinum, and Nitric Acid."

Long Distance Telephony.—At an art exhibition held at Aston (Birmingham), on Wednesday, the visitors had the opportunity of hearing the music at the Savoy Theatre (London), by means of the National Company's new trunk line.

Cork.—The Irish House-to-House Company are going in for an order, and name the following streets as the compulsory area: Patrick-street, Grand Parade, South-mall, Great George-street, Bridge-street, King-street, George's Quay, South-terrace.

A Big Shock.—A telegram from San Francisco, dated November 24, says: An employé of the electric light company here has received a shock which is calculated at fully 1,000 volts. The man escaped with his life, but his hands are burned to the bone.

Legal.—We this week give brief reports of two cases of considerable interest to electric light supply companies and their customers. In one case the company is brought into court for breach of contract to supply current, in the other the consumer is the defendant.

Kidderminster's compulsory area will be Mill-street, Bull-ring, Church-street, Callow's-lane, Trinity-lane, Swan-street, Coventry-street, High-street, Vicar-street, Worcester-street, Oxford-street, Marlborough-street, Bridge-street, New-road, and Exchange-street.

New Cable.—The laying down of the Great Northern Telegraph Company's new cable between Newcastle and Gothenburg, which was begun on the 16th inst., was successfully completed on Saturday. The cable was immediately opened for correspondence.

Scarborough.—The Corporation order names the following compulsory area: Westborough (eastward of the Westborough Wesleyan Chapel), Newborough (westward of King-street), St. Nicholas-street, St. Nicholas-cliff (north of the Grand Hotel), York-place, and the Crescent.

Moscow.—A French exhibition is to be opened here in May next. The lighting will be carried out by the Edison Continental Company of Paris. There will be three engines of 150 h.p. to drive the dynamos. Of course luminous fountains will form one of the attractions.

Aylesbury.—On Messrs. Latimer Clark, Muirhead, and Co.'s application for the consent of the Local Board to their obtaining an order coming up for discussion last week, it was decided to ask within what time the firm would supply the town with electricity if they got an order.

Main Laying.—The London County Council have given their sanction to the laying of mains by the London Electric Supply Corporation, Westminster Electric Supply Corporation, Metropolitan Electric Supply Company, Kensington and Knightsbridge Electric Supply Company.

Sophia (Bulgaria).—It is stated that the contract for lighting Sophia electrically has been given to a Budapesth firm, their tender having been the lowest. The local papers denounce the acceptance of the lowest tender without regard to the ability of the firm in question to carry out the work.

Glasgow Tramways.—On Wednesday, a petition was presented to the Court of Session, Edinburgh, by the Glasgow Tramway Company for sanction to an alteration of its memorandum of association, to the extent of working cars by electricity or steam, and to increase its capital by £150,000.

Underground Wires in New York.—It is estimated that no less than 17,903 miles of conductors have been put underground in New York since 1st Jan., 1889. The authorities are wondering how they are to find room below ground for all the pipes and wires that have got to be put there.

Prof. Ewing.—At a recent meeting of the District Council for Perth, Forfar, and Fife, held at Dundee, a reso-

lution was passed congratulating Prof. Ewing on his advancement, and at the same time expressing the sense of the loss which the Council would suffer by his transference to Cambridge.

Catalogue.—We have received a copy of the Edison and Swan United Company's catalogue, which gives full particulars, with capital illustrations, of every variety of lamp and fitting manufactured by the company. The engravings are very clear, so is the type, and the general get up is good.

The Telephone in France.—From January 1 next it is proposed to reduce the principal subscription to an exchange in towns of less than 25,000 already provided with telephone lines, but with no more than 100 first-class subscribers, to 150f., or £6. The object of this is to encourage what are called secondary circuits.

Rope Driving.—Mr. C. W. Hunt, of New York, in order to ascertain the average breaking strength of commercial rope, purchased four pieces made by different cordage works, and had them tested on the Fairbanks testing machine in New York. They varied slightly in diameter, but when reduced to the equivalent of a rope 1in. in diameter had an average breaking strength of 7,140lb.

Naval Exhibition.—The Royal Naval Exhibition, 1891, has been incorporated under the Companies Acts, and was registered on the 21st inst. as an association limited by guarantee by license of the Board of Trade. The president is the Prince of Wales, Honorary Admiral of the Fleet; the chairman of the executive committee is Admiral Sir W. M. Dowell, and the vice-chairman, Admiral Sir W. Houston Stewart.

St. Martin's-in-the-Fields (London, W.C.).—Messrs. Latimer Clark, Muirhead, and Co. have given notice of their intention to apply for an order for this district, the compulsory area to include Cockspur-street, Charing Cross, Trafalgar-square, Northumberland-avenue, Whitehall-place, Whitehall, West Strand, part of Strand, St. Martin's-place, St. Martin's-lane, part of Charing Cross-road, Pall-mall East, and Haymarket.

Appointment.—It is announced that the Mutual Telephone Company, Limited, have secured the services as general manager and chief engineer for a term of years of Mr. A. R. Bennett, who in July last resigned his position as general manager in Scotland to the National Telephone Company. Mr. Bennett's headquarters will be in London, and we understand that he has reserved power to practise as a consulting engineer and electrician.

Society of Arts.—The second Cantor lecture will be given by Prof. Vivian B. Lewes, on Monday next. The subject dealt with will be: The composition of coal-gas; the illuminants present in coal-gas; effect of class of coal, methods of manufacture, and diluents present, on the illuminating power of coal-gas; the methods employed to enrich coal-gas. On Wednesday, December 3, Mr. James Dredge is to read a paper on "The Chicago Exhibition, 1893."

Electric Construction Corporation.—We give the report of the directors of this corporation in another column. The accounts show a profit of £52,639. 3s. 2d. A dividend of 6 per cent. is proposed. It is also proposed to increase the capital by issuing debentures. From the profit the expenses of the formation of the company have been written off; they amounted to £4,348. 7s. 6d. The directors recommend that £15,000 be placed to the reserve account against depreciation.

Swan United Company.—A full report of the meeting of the proprietors of this company is given elsewhere. It will be seen that they hope before long to be rid of their litigation difficulties, and then infringers in Germany and France (provided they are proved to be such) may look out for squalls. Another probable result of the settlement of the litigation will be the amalgamation of the Swan United and Edison and Swan companies.

Testing Stations.—The London County Council's Bill will contain a clause giving the Council power to require any electric lighting company to supply electrical energy to the Council's electric testing stations, even if the station for which the supply is required be beyond the limit of the company's area of supply, and authorising such company, subject to the usual notices, to break up streets for the purpose of laying the mains necessary to afford such supply to the testing stations.

West Metropolitan Tramways.—The Hammersmith Vestry, at a recent meeting, unanimously agreed to the proposal of the West Metropolitan Tramway Company to work the line from the Uxbridge-road Station to Kew, a distance of three miles, by the Lineff system of electrical traction. Reports by Mr. W. H. Preece, chief electrician to the Post Office, Mr. Gisbert Kapp, C.E., and Prof. Robinson, approving of the Lineff system, were laid before the Vestry. It is understood that the work will be commenced without delay.

Electric Lighting in Poona.—The Cantonment Committee have been discussing a scheme for the electric lighting of Poona. It is stated that London firms have offered to form a syndicate to raise two-thirds of the capital required if the Cantonment Committee will guarantee the remaining one-third. The matter has been referred to a sub-committee for a report. In the meantime the Government were to be asked to say whether, if electric light was introduced into Poona, they would have the barracks and public buildings similarly lighted.

Electrical Trades' Union.—We have been asked to insert the following notice: "All members are urgently requested to attend headquarters on Saturday, November 29, at 8 p.m., for the election and instruction of delegates to the forthcoming convention to be held at Liverpool on December 6." We have complied with the request, but if this union be simply another branch of unionism intended to agitate and maintain paid agitators, we have no sympathy with its action, and look upon its members as forming a section of Carlyle's largest class of humanity.

Separating Copper from Arsenic.—If the current of four or five cells is passed through an arseniate solution, rendered alkaline by means of ammoniac, no separation or reduction of the arsenic acid takes place; but if a solution of copper salts is so treated, there is a complete separation of the copper. This difference of action has, according to *Electrotechnische Zeitschrift*, been utilised to separate arsenic from copper. The experiments were made with solutions prepared beforehand, and after 24 hours it could be ascertained by weighing that all the copper was deposited.

Detecting Water Leaks.—Mr. A. H. Brown, of New York, has applied a simple circuit-closing device to the detection of water leaks from baths, cisterns, etc. When any pipes or glands leak, or an overflow occurs on any floor, the water drips into a pan and flows into the

bucket valve of the detector. When the quantity equals a tablespoonful the valve falls by the weight of the water and brings the free end of the lever against the contact points in the annunciator circuit, closing it and ringing a bell, whilst an indicator shows the room from which the alarm has come.

Science Demonstrator Wanted. — The School Board for London are in want of a science demonstrator, who will be required to visit schools under the direction of the Board, for the purpose of giving instruction in mechanics, etc. Salary is £175 a year, rising by £5 annually to a maximum of £200 a year, together with travelling expenses for the conveyance of apparatus from school to school and for assistance in experiments. Forms of application may be obtained from the clerk of the Board, Victoria-embankment, W.C., and must be sent in by December 4th.

Carbon Shield for Arc Lamps. — Mr. W. B. Hazeltine, of the Hazeltine Electric Company, St. Louis, has introduced a shield for arc lamp carbons, consisting of a sleeve of refractory material, which forms a protective covering. This is suspended freely so as to hang in close proximity to the tip of the upper carbon near to the arc, the suspension device being so arranged that the sleeve is automatically maintained at its proper position. Experience seems to show that by its adoption the life of the carbon is practically doubled by the absence of side waste thus obtained.

Glasgow.—Mr. Foulis, the chief gas manager to the Corporation, has, by instruction of the Special Committee on Electric Lighting, compiled a report based on data which he has collected with regard to about 40 electric lighting undertakings, corporations, and companies throughout the kingdom. It has not yet been decided by the committee whether they will recommend the Corporation to start a lighting station of their own, or to contract with one or more companies to undertake the lighting of the area which is made compulsory on them by their provisional order.

Australian Cable Rates.—A Reuter's telegram from Melbourne, dated November 25, says: The Government of Victoria has decided to propose to the Legislature the adoption of the cable guarantee required by the telegraph companies to enable them to put into force the projected reduction of rates. The Government of Western Australia has likewise agreed to take similar action. It is also probable that New South Wales and South Australia will join in the guarantee. It is now the prevalent opinion here that the reduced rate will be brought into force from the commencement of next year, irrespective of the fact that the colonies of Queensland and New Zealand have declined to bear their share.

Leeds.—The Yorkshire House-to-House Company's notice of intention to apply for an order for Leeds names the following streets as forming the compulsory area: Briggate, New Briggate, Kirkgate (from Briggate to Vicar-lane), Boar-lane, Wellington-street (from Boar-lane to the Central Railway Station), Infirmary-street, King-street, York-place, Park-square, St. Paul's street (from King-street to Queen-street), Park-lane, East Parade, Bond-street, Commercial-street, Park-row, Cookridge-street, Albion-street, Lands-lane, Upperhead-row, Woodhouse-lane, Headingley-lane. The National Electric Supply Company have also applied for an order. The Corporation will not apply.

Patent Office Library.—A correspondent has been complaining of the execrable light provided in the Patent Office library, where readers have to provide themselves with magnifying glasses and stand under special gas lamps which are favourites, for their extra radiance. It seems a pity that these precincts, which have been so patronised by electrical patentees, cannot have the benefit of their researches spread to its dim cloisters. One would even think it might be worth while for a primary battery company to provide light free of charge; or that the authorities should be at least equally deluged with offers of light for themselves as the head office is deluged with inventive specifications of means of producing it.

The Dangers of Electric Lighting.—At the meeting of the London County Council on Tuesday, Mr. Hopkins asked the chairman of the Fire Brigade Committee (Mr. Lyon) a variety of questions as to what danger, if any, there was in electrical lighting, and particularly to the centres of electrical storage, he referring to a fire which occurred recently, the cause of which was said to be the overheating of an electric wire, and whether he had any objection to the Fire Brigade and Highways Committee considering the matter. Mr. Lyon replied that the statement as to the fire in question having been caused by the overheating of an electric wire was not an official one; it was a newspaper statement, which was not official.

Brazil.—Company promoters will not find Brazil much of a happy hunting ground in future. The Government have just issued a decree altering the law as to the formation of limited liability companies. The first two clauses run as follows: (1) Henceforth limited liability companies will not be considered definitely constituted unless the whole capital has been subscribed, and 30 per cent. in money of the value of each share has been actually deposited in a bank to be selected by the majority of the subscribers, unless a larger percentage has been stipulated in the prospectus. (2) Also the shares of limited liability companies which shall hereafter be formed, shall not be negotiable until 40 per cent. of the capital subscribed has been realised. In these transfers procurations in *causa propria* are prohibited.

Carlow (Ireland).—At the meeting of the Town Commissioners last week a letter was read from Messrs. J. E. H. Gordon and Co., London, asking permission to supply electricity for lighting purposes in the town, and in case of the Board acceding to their request, proposing to light the streets with 12 arcs and 40 incandescents of 16 c.p. during the usual lighting season on receiving a guarantee that the Board will assist Messrs. Gordon in their application for the privilege of private supply. Mr. Tomlinson, chief engineer to the firm, appeared and stated that he had gone over the area lighted at present, and detailed the sites for the 12 arc lights, whilst the incandescent lamps were to light the streets beyond the reach of the illumination of the arc lights. The Board gave Mr. Tomlinson permission to erect specimen lamps.

The Southend Local Board have authorised the volunteer fire brigade to cross roads with electric call-bell wires. Some discussion arose at a recent meeting as to a recommendation of the Pier Committee that one of the three tramway cars included in Messrs. Crompton's contract be a closed car, instead of an open one, at an increased cost of £95. An amendment was, however, adopted that the cars be provided as set forth in the contract. The work on the pier is progressing so slowly that Messrs. Crompton

have had to write that unless it goes on more rapidly they will be seriously delayed in their part of the work—viz., the lighting and electric tramway. The Local Board's notice of application for a lighting and supply order gives as the compulsory area: Whitegate-road, Queen's-road, London-road, Southchurch-road, Clarence-road, York-street, York-road, Heygate-avenue, Royal-terrace, East-parade, Brewery-road, East-street, North-street.

The Western Counties Telephone Company.—We understand that Mr. Lewis, the energetic manager of this company, contemplates a new departure in Bristol in connection with the Messengers' Association. He has made arrangements by which subscribers can immediately obtain the services of a respectable and responsible messenger by "ringing up" a certain number, in this case No. 410. The payment of these messengers by distance is 1d. per half mile. Paid by time, the charge is 1d. for 10 minutes, 4d. for one hour, 6d. for two hours, 8d. for three hours. Under the head of regular work, a messenger may be got for one hour daily at 1s. 9d. per week; for four hours daily at 4s. 3d. per week. Another feature of the telephone system in Bristol is that the exchange is connected with the various cab stands at different points in the city, so that a cab may be called at any moment, and the same applies to the police and the fire brigade stations.

Telegraph Clerks and their Grievances.—It is stated that a good deal of ill-feeling has been occasioned amongst the clerks of the Central Telegraph Office in consequence of the forbidding of a meeting which was to have been held November 21, 1890, for the purpose of presenting an address, a medal, and a cheque for £500 to Mr. L. H. Quin. Acting in accordance with the circular of May last, which directed that due notice should be given to the Department of all meetings of Post Office officials, the organisers of the meeting sent a notice to the Postmaster-General. Mr. Raikes, in reply, referred to the fact that Mr. Quin was dismissed for misconduct, and stated that he regarded the holding of a general meeting of the staff for the purpose mentioned as in the highest degree improper, adding that any officer of the Department who should take part in such a proceeding would be held strictly responsible. The presentation accordingly took place privately.

The Telephone for Hospitals.—Patients in fever hospitals are at present unable to talk with friends and relations until released, not only from the bonds of scarlet fever, typhoid, or smallpox, but also from the sick wards. There is nothing, however, to prevent their telephoning to such among their acquaintances as will venture into the precincts of the hospital. Naturally we hear this idea has been put into practice in America, though no doubt it has long been talked of in England. A New York doctor has completed telephonic circuits between the wards of the City Hospital and the reception-rooms, so that patients suffering from infectious diseases may communicate with their visitors. A board in the reception-room contains the names of the patients, and an attendant has only to put the jack into the hole beneath any name when any friend desires to speak with the occupant of a cot upstairs. This has been found to work with great success, and the plan is to be adopted by other hospitals. We commend the innovation to the London Fever Hospital among others.

Electric Cars Can Mount Steep Grades.—Describing the excursions of the Iron and Steel Institute in Alabama, the *Iron and Coal Trades' Review* correspondent says: "The ascent to Mission Bridge, which is some 500ft. above the level of Chattanooga, was made in electric cars, which contained about 30 passengers each, and ascended one by one long grades of 7½ per cent., and passed occasionally round very sharp curves. The current is supplied, as is the common plan in the United States, through an unprotected wire over the centre of the track. A trailing bowsprit, with a double-flanged pulley sheave at the end, furnishes a conductor, by which the current passes down through the car to the two motors which drive the two axles, and thence passes to earth through the wheels and rails. An eccentric on one of the axles works an air pump, which is in connection with the vacuum brake. This last is relied upon to control the speed in descending the grades. This journey in electric cars was extremely valuable to the English visitors, as showing what steep grades can be safely and rapidly ascended and descended by that means. They could not fail to be convinced that American practice in this respect is far ahead of anything known in England; also that the practice of having an electric wire overhead suspended from posts is an exceedingly convenient and unobjectionable way of accomplishing the object, and that the popular prejudice against it is, to a large extent, unwarranted." English local authorities, please note!

Overhead Wires.—The London County Council's Bill provides for dealing with overhead wires, when it is passed. The term "wire" is to apply to all overhead conductors within 50ft. of a street, but railways are specially exempt. The Council may provide subways, and compel all companies or others owning wires to remove the same from overhead and carry them underground, either in their own subways or the subways of the Council, who will have authority to make a rental charge. There will also be fees payable in respect of all wires allowed to remain or to be hereafter erected overhead. All objections which owners of property may have to wires being carried over or attached to their premises will be considered and decided by the Council, subject to an appeal to an arbitrator appointed by the Board of Trade. The decision of the arbitrator is to be final and binding on all parties, but not in any way to interfere with an owner's rights in respect of his property, which he will be at liberty to rebuild or alter as may be necessary even if the removal of the wires is involved. The Council is in all cases to give notice to the Postmaster-General before making any order under the statute, and the Postmaster-General may veto the proposal if in his opinion it would be prejudicial to the postal telegraph service. Authority is asked for the appointment of inspectors of wires, and for right of entry upon private premises, and all penalties recovered are to be paid to the Council, the City Commissioners of Sewers, or the local authority taking proceedings under the Act.

City and South London Railway.—A number of trains, each consisting of an electric locomotive and three carriages, have been running regularly for some days on this railway in order to educate the staff in the working of the electrical plant, the hydraulic lifts, and other matters which are peculiar to the undertaking. It is expected that the final inspection of the Board of Trade will take place within a few days, and the line will then be open to the public. On Monday, the 24th inst., on the recommendation of the Prince of Wales, who recently inaugurated the completion of the undertaking, H.S.H. Prince Hermann of Saxe-Weimar privately visited the railway. He was accompanied by Major Cardew, representing the Board of Trade, and was met at the City Station by Mr. C. J. Mott, the chairman of the company, Mr. Greathead, the engineer,

Mr. Jenkin, the general manager, and Mr. Basil Mott, resident engineer, and proceeded at once to the special train which was awaiting him at the King William-street Terminus. Here he was met by Mr. Wm. Mather, M.P., and Dr. Edward Hopkinson, and Mr. Grindle, the resident engineer of Messrs. Mather and Platt. The train rapidly made the journey to Stockwell, stopping at each of the intermediate stations. At Stockwell the boiler-house, engine-house, and carriage-sheds were examined, and the electrical working was explained by Mr. Mather and Dr. E. Hopkinson. On the return journey the Prince expressed a desire to travel on the electrical locomotive, so as to more clearly inspect its working. The Prince expressed himself as very much pleased and gratified with all he had seen.

Electric Lighting and Gas in America.—Two weeks ago we commented on a crumb of comfort offered for the digestion of gas managers by a shareholder in the Imperial Continental Gas Association. This week we reproduce a crumb of wisdom offered to the same class of gentlemen by a member of their own body, in America. At a recent meeting of the American Gas Light Association, the president, Mr. Emerson McMullin, of St. Louis, said: "The twin industry, electric lighting, has, during the last year, been making strides unparalleled. Its progress since the first light was commercially used is almost beyond conception. Like water-gas, this industry was first received by the members of our association as a subtle enemy of the gas business. Now it is said that more than 300 gas companies employ it; some with the result of increasing their dividends, while others are apparently using it as an agency for disbursing surplus. An authority asserted a year ago that there were then 300,000 arcs and 3,000,000 incandescent lights in the United States. There must be many more now. When we remember that 20 years ago there was not an electric light commercially used in all the world, we may well be amazed at the progress made. I need not tell you that not all of this wonderful success had been due to the real merits of electric lighting. Part is due to merit, part to the charm that attaches itself to anything new, but a greater part to intelligent promotion, energetic and scientific management, and to astonishing liberality. Officers of many gas companies might with profit sit at the feet of some electric managers and gather crumbs of wisdom. Possibly in the not far distant future your council will recommend to the association an amendment to the constitution. The amendment will strike out the word 'gas' in the name of the association, or suggest the alternative proposition to add the words 'and electric.'"

Electro-Harmonic Society.—The next concert will take place on Monday, December 8th (instead of the usual Friday), at the St. James's Hall Restaurant (Banquet-room), at 8 p.m. This is a ladies' night. We give the programme herewith, merely premising that the orchestra mentioned therein will be composed as follows: First violins, Miss Doughty and Mr. T. E. Gatehouse (principal); second violins, Messrs. Raaschon, Dunn, and Sherwin Richardson (principal); viola, Mr. C. H. Allen; violoncellos, Miss Dora Pearce and Mr. Behm (principal); contra-basso, Mr. Brewer; harp, Mr. G. T. Miles; piano, Mr. Alfred Izard; accompanists, Mr. Alexander Siemens and Mr. Alfred Izard; musical directors, Mr. T. E. Gatehouse and Mr. Arthur Thompson. Programme—Part I.: Overture, "Le Nozze de Figaro" (Mozart), the orchestra; song, "The Bedouin's Love Song" (Pinsuti), Mr. Gordon Heller; violin solo, "Ballade and Polonaise" (H. Vieuxtemps), Mr. Theodor Raaschon; gavotte (entr'acte), "Mignon" (Ambroise Thomas), the orchestra; song, "Loch Lomond" (old Scotch ballad), Mrs. Alexander Siemens; songs, (*a*) "Death and the Maiden" and (*b*) "Hark, Hark, the Lark" (Schubert), Mrs. Alexander Siemens; harp solo, "The Bells of Aberdovey" (Thomas), Mr. G. T. Miles; musical sketch, "The Silver Wedding" (Geo. Grossmith), Mr. F. Charlton Fry; violin duet, "Grossmütterchen" ("Little Granny") (O. Langey), Miss Doughty and Mr. Gatehouse, accompanied by orchestra. Part II.: Overture, "La Siréne" (Auber), the orchestra; violin solo, "Adante and Finale" (Mendelssohn), from Concerto in E minor, Mr. T. E. Gatehouse; song, "Let the Dreadful Engines" (Purcell), Mr. Gordon Heller; selection, "Largo" (Handel), the orchestra (violin solo, Miss Doughty); piano solo, "Wedding March" (Greig), Mr. Alfred Izard; humorous song, "The Parents" (Harraden), Mr. F. Charlton Fry; finale, "March" from Suite (Lachner), the orchestra.

Institution Dinner.—The second annual dinner of the Institution of Electrical Engineers was held on Thursday evening last week, many distinguished gentlemen being present, besides members of the Institution. Among them were: The Right Hon. Cecil Raikes (Postmaster-General), Sir Richard Webster (Attorney-General), Mr. W. H. M. Christie (Astronomer-Royal), Sir Arthur Blackwood (secretary, General Post Office), Sir Geo. Stokes (president, Royal Society), Mr. J. Tomlinson (president, Mechanical Engineers), Dr. Coleman Sellers (International Niagara Commission), Sir Douglas Dalton, Major Marindin, Capt. Wharton, Sir Jas. Douglas, Sir Jas. Anderson, Herr Fritsche, Major-General Stotherd, Sir H. Trueman Wood (secretary, Society of Arts), and many others. Mr. Raikes, in returning thanks for the toast of "Her Majesty's Ministers," alluded to the progress made in electrical science, and pointed a happy speech by a happy classical quotation embodying the threefold characteristics of electricity:

> "Terret, lustrat, agit Proserpina, Luna, Diana,
> Ima, suprema, feras, sceptro, fulgore, sagittâ,"

which he ventured to paraphrase in these lines:

> "Our threefold goddess, with her magic spells,
> By turns alarms, enlightens, and impels,
> While hangs the pale exchange upon her strings,
> Her lamp cheers cities, and her touch gives wings."

Sir George Stokes and Mr. W. H. Preece alluded to the fact that the next president of the Royal Society would be their last year's President of Electrical Engineers, Sir Wm Thomson. The Attorney-General announced his intention of agreeing to join the Institution on the invitation of Sir David Salomons, on the distinct understanding that they admitted "duffers" as well as scientific men, a statement which caused much amusement. Dr. Coleman Sellers stated that the function of the International Niagara Commission, on whose behalf he was in England, was not a financial, but an engineering one, the commission wishing to have the use of the best brains they could procure. They intended to utilise the comparatively small amount of 120,000 h.p. out of the immense energy now going to waste at Niagara Falls. Mr. Raikes also proposed the "Institution of Electrical Engineers," acknowledging the indebtedness of both Government and public to the science, and looking forward to the vast field which, at the expiry of the telephone patents in a year or two, would be opened to the inventive genius of electrical engineers. The President (Dr. John Hopkinson) briefly replied.

COMMON-SENSE PIONEERS.

The present decade is one which has given birth to inventions and undertakings in electrical science destined in the near future to have as widespread an influence upon the world as the introduction, for instance, of the railway locomotive by Stephenson has effected. It is due to the present workers in these fields to remember that we have amongst us men who hold in their hands the destinies of future generations; men whose names are as likely to be as renowned in later years as that of Stephenson and Watt in this. It is therefore always with a thrill of interest that men of these days approach to the inner feeling of the men of the earlier inception of great undertakings, and it is with a feeling of satisfaction that we note that a grand commonsense, and a lofty feeling of uprightness in action, characterises those who are destined to have their energies yield the fruitfulness of national prosperity.

At a recent meeting of a private literary society which took place at the house of Prof. Silvanus Thompson, an interesting paper was read by Mr. William Beck, jun., describing the inception and initial stages of the steam railway at the time of Stephenson. Not the least interesting part of an interesting paper was an original note contributed by his uncle, William Beck the elder, upon the character and methods of Stephenson himself, and we think it may be found of sufficient personal and historical interest to be given to a more extended public. It was Edward Pease—the Quaker of Darlington—who, working with Stephenson as engineer, furnished capital to carry through the first railway line, which, from the connection of several other members of the Society of Friends, was known as the "Quaker's Railway." Mr. Beck gives the following information as coming direct to him in a memorable conversation it was once his privilege to have with Mr. Pease:

"As to Stephenson's education, or rather non-education, Edward Pease said he was unable to calculate by arithmetic, but could in an astonishing manner determine in his mind without putting down on paper what amount of work was needed, and the relative proportion between earth that had to be removed in cuttings and earth that would be wanted for embankments.

"His shrewd common-sense way of obtaining the desired end was more conspicuous in his character than what might be termed genius. Thus, for example, when desirous of setting the distance apart of the rails, he studied and adopted as his gauge that which traffic on common roads had already decided for carriages, whilst Brunel studied the question abstractly and scientifically, and achieved a higher rate of speed in consequence, but common-sense and general practice have favoured Stephenson's rather than Brunel's gauge.

"His stern honesty and rectitude, Edward Pease said, made an early impression on himself and his co-directors, and to the confidence thus established between them great results were due.

"The rails, for example, were at first made of cast iron, and Stephenson had a patent for some improvement he had effected in their form, but when it became a question as to what kind of rail should be adopted for the Stockton and Darlington Railway, Stephenson emphatically declared himself in favour of wrought iron. Such, it must be remembered, were much more costly in those days than the cast ones, for the rolling machinery necessary to their economical production had not been invented; nevertheless, Stephenson's advice was to the directors, 'Go to this expense and use wrought iron for your metals.'

"'Never to my mind,' said Edward Pease, 'did a man act more honestly towards his employers. The other course would have brought him a large and immediate profit. We felt he was speaking to us what had become to him an assured truth when he told us, "I have tried both, and I find wrought iron wears the best, and though the dearest at first will prove the cheapest in the end and the safest, for they won't break like the cast metals," and thus were we led, contrary to our then opinions, to use wrought-iron rails instead of cast, and we found the colliery engineman was right again.'

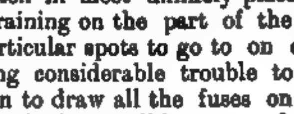
"As to the now called 'locomotive,' its birth on the Stockton and Darlington arose from Stephenson's earnestness in its favour, for Edward Pease and his brother directors were looking, like plain, simple men, to horse traction alone. 'But come,' said George to them, 'and see my fire horse. It will do more than your cattle,' 'and so one day' (continued this patriarch of railways) I went with Birkbeck (who was one of his chief friends among the directors), 'to see George's fire-steed, and he put us upon it, and ran alongside poking at the fire; it did go, but it wouldn't for all that go as fast as George ran.' It was still a mere chick, rude and slow, but those two good 'Friends' felt they had ridden on what had great possibilities before it, and thereupon started a factory for the making of George's fire horses. So that memorable day was in reality (little as the actors in the scene knew it) the birthday of the English locomotive, and the origin of the Newcastle factory for making them."

DRAKE AND GORHAM'S SLIDING FUSE.

In our description of the installation at Madame Tussaud's last week we alluded to an improved type of fuse-box, introduced in its present modified form under the direction of Mr. Kapp for the occasion, by Messrs. Drake and Gorham, and likely, we think, to have an extended usefulness. In the earlier stages of electric lighting the

Drake and Gorham's Fuse.

custom was to distribute fuses about in all and sundry places, in the ceiling roses, on the ceiling, in the corners of moulding, on the wall, the wainscoting, etc., almost anywhere, in fact, often in most unlikely places, and necessitating a special training on the part of the attendants to remember the particular spots to go to on extinction of a light, and causing considerable trouble to replace. The tendency has been to draw all the fuses on any one floor together to a special place well-known and properly safeguarded, with glass cover for easy inspection, and from this



Single Fuse.

place to run all the wires which the fuses protect. Fuse-boxes of this type have been in almost exclusive use with many contracting firms for some time and have proved their usefulness. The illustration which we give of the latest arrangement of Drake and Gorham's fuse explains itself. The contacts, instead of being made by screwing down the fuses, are made by simply slipping in the fuse plugs. These are made of the form shown, a fusible wire mounted on an insulating bar, and can each be separately slipped in without trouble, without disturbing the other contacts, and still retaining the short length of wire stretched free in air. The fuses are each marked with the current they will carry; and in fixing the boxes each contact is also plainly marked, so that there may be no fear of the insertion of the wrong fuse. The design allows easy manipulation and a perfect contact however unskilled may be the attendant.

ELECTRIC CRANES.

Among the application of electric motor power to practical purposes, that of electric cranes is evidently destined to find an extended field of usefulness, when its simplicity and cheapness becomes more known and appreciated. Quite an installation of motors for crane work has been erected on the wharfs of Messrs. Fellowes, Morton, and Clayton, Limited, at Wharf-road, City-road, where four out of the six or seven cranes in constant use have been fitted with electrical gear. This work has been carried out by Mr. W. D. Sandwell, of Victor Works, Holloway, who has constructed both the generating dynamo, the motors and switches, and also the necessary gearing for the alteration. One of these cranes has been driven electrically for over a year, and having proved its usefulness three others in the same yard have been also fitted, and have run with great satisfaction for the last three months. The largest is a 12-ton derrick crane; the others consist of one 2-ton crane, and two 30cwt. cranes of more or less modern type. These in their times have undergone many transformations, from the original hand gearing to steam, and from steam back to hand, and now to electricity, with which, it is to be hoped, and certainly seems to be expected, that the owners will remain content.

The power is obtained from a 12-h.p. nominal Otto gas engine, which is used besides for driving chaff-cutting machinery and friction hoisting, the power used for the electrical cranes being about 6 h.p. The gas engine is connected to the dynamo by countershafting and fast and loose pulley. The dynamo, of the two-pole upright type, with Gramme armature, gives 160 volts and 40 amperes. The arrangements are all of the simplest and most direct description, no skilled labour, or mechanic, or electrician being employed, all the work, both in driving, hauling, and attending to the dynamos and motors, being done by ordinary wharf labourers engaged on the place. The wires from the dynamo are taken through a main switch to the centre of the high roof, and from here distributed in parallel to the four motors. The cranes being all of different type and make, each one has had to be fitted and mounted with motor and gearing according to its shape and requirements. In one the motor is bolted to the stand-plate, to another side plates have been cast, planed, and fitted, and the motor slung in between these in the most compact way possible. One of the motors is of 2½ h.p., the other three being 2 h.p., geared to the requirements of the lifting power of the various cranes. Each motor is geared direct to cog-wheel pinions and drives backwards and forwards for hoisting and lowering by means of a reversing switch. The switch is arranged in the simplest possible way, with two handles—one for reversing, and the other for starting and stopping—with three resistances in the armature circuit. These handles are all that shows to the workman, and are fixed; but to each switch there is a plug which the workman carries in his pocket for insertion into a plughole before starting. This acts as a main switch plug and fits all the motors. The cranes are thus under complete control for hoisting and lowering, and are further furnished with powerful strap brake. The current used is usually about 12 or 15 amperes, never over 20 amperes, so that the dynamo is able (and will probably be made) to supply one or two other cranes. It is seldom found that three or even two cranes are working at the same time and for three cranes to be hoisting at exactly the same moment is almost beyond chance of possibility—a fact which allows a moderate sized dynamo to supply quite a number of hoists. The brushes on the motors are of solid carbon bars as used in America. The fixed position of the brushes causes more sparking than is usually allowed, but the directness of the method of connection for backward and forward working has been considered better than attempting to run always one way. The cranes, on our visit, were at work loading and unloading goods, and seem to be in great favour with the men for quickness and ease of manipulation.

But besides this the great advantage is cheapness. The cost of working the cranes by steam is given at £5 per week for fuel alone, working night and day as they do; while for gas in the gas engine by electric means the cost for the four cranes is only £2 a week. The cost of the whole installation (without the gas engine) including shafting, dynamo, wiring, motors, gearing, and fitting and altering cranes, was a little over £300, with a contract for keeping them in order for £30 a year. Mr. Sandwell is intending to make a speciality of electric crane work, and has secured orders for over £2,000 worth of this class of work. He is able to construct and supply a 2-ton electric crane, including everything, except engine—that is, crane, dynamo, motor, and gearing—for something over £100, which is only about half the cost of a steam crane plant. Electric cranes, therefore, would be economical both for first cost as well as for cost of running in such cases where engine power was to spare, or a gas or steam engine was required for other purposes, such as saw mill work, or, again, where several cranes are required for use on one factory or wharf. We should think this example of one of the largest of London wharfage firms will be productive of good results upon electric motor work by the introduction of electric cranes on many similar wharves, and at other works where rapid transfer of goods is a necessity.

MAGNETISM AND RECALESCENCE.*

BY J. HOPKINSON, D.Sc., F.R.S.

In my experiments the results of which are published, *Phil. Trans.*, 1889, A, p. 443, I showed that recalescence and the disappearance of magnetisability in iron and steel occurred at about the same temperature. The evidence I then gave was sufficiently satisfactory, but did not amount to absolute proof of the identity of the temperatures.

FIG. 1.

Osmond has shown that the temperature of recalescence depends upon the temperature to which the iron has been heated, also that it differs when the iron is heated and when it is cooled. He also showed that for some sorts of steel the heat is liberated at more than one temperature, notably that in steel with 0·29 per cent. of carbon heat is liberated when cooling at 720deg. C. and at 660deg. C., and that with steel with 0·32 per cent. carbon there is a considerable liberation of heat before the temperature is reached when this becomes a maximum. It appeared to be desirable to obtain absolute proof that the change of magnetic property occurred exactly when heat was liberated and absorbed, and to examine, magnetically, Osmond's two temperatures of heat liberation. I have not been able to obtain samples of steel of the size I used, showing two well-marked temperatures of heat liberation and absorption, but I have a ring in which there is liberation of heat extending over a considerable range of temperature.

The samples had the form of rings of the size and shape indicated in Fig. 1. A copper wire was well insulated with asbestos and laid in the groove running round the ring, and was covered with several layers of asbestos paper laid in the groove. This coil was used for measuring temperature by its resistance. The whole ring was served over with asbestos paper and with sheets of mica. The secondary exploring coil was then wound on, next a serving of asbestos paper and mica, and then the primary coil, and, lastly, a good serving of asbestos paper was laid over all. In this way good insulation of the secondary coil was secured, and a reasonable certainty that the temperature

* Paper read before the Royal Society.

The undersigned beg leave, therefore, most respectfully to request the Board of Trade to give the decision therein communicated their favourable consideration, and to suggest that this rule may be modified in accordance with the following:

Every high-pressure aerial conductor must be continuously insulated with a durable and efficient material, to be approved of by the Board of Trade, and to a thickness of not less than one-seventh part of the actual conductor diameter, in cases where the extreme difference of potential does not exceed 2,000 volts; but for all higher voltages this thickness must be increased in direct proportion to the increase in difference of potential.

In no case must the thickness of insulation be less than one-sixteenth of an inch, and the cables must have an insulation resistance of not less than one megohm per mile per volt of electromotive force when tested in water at 60deg. Fahr. (after immersion of at least 60 consecutive hours). This insulation must be further efficiently protected on the outside against injury or removal by abrasion. If this insulation or protection be wholly or partly metallic, it must be efficiently connected to earth, so, however, as not to cause undue disturbance to other electric lines or works by electrostatic induction or otherwise.

The undersigned are willing and anxious to conduct any additional tests which the Board of Trade may wish or suggest in proof of the contentions herein stated.

The undersigned make these representations while fully recognising the necessity in the interests, not only of the public, but also of the electrical industry generally, that all overhead electric lines should be carried out in the safest possible manner.—We have the honour to be, Sir, your most obedient servants,

(Signed) THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED.
MESSRS. CROMPTON AND COMPANY, LIMITED.
THE INDIA RUBBER AND GUTTA PERCHA COMPANY, LIMITED.
THE LAING, WHARTON, AND DOWN CONSTRUCTION SYNDICATE, LIMITED.

London, November 6, 1890.

To the Right Hon. Sir Michael Edward Hicks-Beach, Bart., M.P., President of the Board of Trade.

SIR,—We, the undersigned companies, firms, and persons interested in the supply of electricity in the United Kingdom, beg respectfully to memorialise your Board with reference to regulations Nos. 2 and 12 of Regulations for the Protection of the Public Safety, etc., prescribed by the Board of Trade under the provisions of the Electric Lighting Act of 1889.

With reference to these regulations, the undersigned beg leave to bring before the Board the fact that in conjunction with overhead conductors having a small sectional area of copper, the use of suspending wires is not only unnecessary, but exceedingly dangerous to public safety, on account of the large surface presented to wind and snow, and the great strain put upon the supports.

It is admitted that this does not apply with so much force to the use of suspending wires with the conductors of relatively large sectional area, but the undersigned are strongly of opinion that both in the interests of the electrical industry, and in those of public safety, it is advisable that overhead conductors, up to a sectional area of hard drawn copper equivalent to seven No. 16 S.W.G., should be run without suspending wires.

The undersigned beg leave, therefore, most respectfully to request the Board of Trade to give their favourable reconsideration to the foregoing regulations, and to suggest that they may be modified in accordance with the following:

Clause 2. Every aerial conductor shall be attached to supports at intervals not exceeding 200ft. where the direction of the conductor is straight, or 150ft. where this direction is curved, or where the conductor makes a horizontal angle at the point of support. If suspending wires are used, as required in Clause 12, the above intervals may be increased to 250ft. and 200ft. respectively.

Clause 12. Every aerial high-pressure conductor shall be efficiently suspended by means of non-metallic ligaments to suspending wires, so that the weight of the conductor does not produce in it any sensible stress in the direction of its length, and the insulated conductors and suspending wires where attached to supports shall be in contact only with material of highly insulating quality, and shall be so attached and guarded that in case they break away it shall not be possible for them to fall away clear of the supports. Provided, that where the aerial high-pressure conductor is equal to or less than seven No. 16 S.W.G., the suspending wires shall not be compulsory if the conductor be of hard-drawn copper, or other material of equal strength.

The undersigned are willing and anxious to conduct any tests which the Board of Trade may wish or suggest, in proof of the contentions herein stated.

The undersigned make these representations while fully recognising the necessity, in the interests, not only of the public, but also of the electrical industry generally, that all overhead electrical lines should be carried out in the safest possible manner.—We have the honour to be, Sir, your obedient servants,

(Signed) THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED.
MESSRS. CROMPTON AND CO., LIMITED.
THE LAING, WHARTON, AND DOWN CONSTRUCTION SYNDICATE, LIMITED.

MINE LIGHTING.

Mr. R. Oliver G. Drummond, electrical engineer to the De Beers Consolidated Mines, Limited, of Kimberley, South Africa, has designed the following fittings with the view of overcoming the difficulties met with in mine lighting. The apparatus is being manufactured by the Electrical Engineering Corporation. The switches and fuses are mounted on specially-designed bases, insulated from the bolt that secures them to the timber or roof, and fitted with a cover to keep off the dust, etc., and to protect the workmen from shocks. The wires are drawn in from the lower side of the base, and consequently the dripping water cannot run up the lead into the switch or the fuse. With these fittings there cannot be any appreciable leakage, except where there is a large amount of moisture in the air and consequent condensation on the sides of the insulated bases. The lamps are suspended from a holder fitted inside a porcelain insulator, which is of such a shape that it becomes a reflector to the lamp, throwing the light downwards, and the heat of the lamp rising into this insulator keeps it warm and dry, no matter how full of moisture the air is. Any water dripping on to it from the roof runs off the outside of it, so that the lamps and holders are thoroughly insulated, and faults from bad insulation are impossible. The bracket lamp is designed of a shape suitable for fixing to the sides of a tunnel, and is fitted in an insulator with the same results as the hanging lamp. The reflector in this case is of such a shape that the light is thrown upwards, downwards, and sideways. When it is necessary to hang lamps in very wet places the combination fitting is recommended, as the switch and cut-outs are arranged inside the reflector or porcelain insulator, and, as will be seen, the heat of the lamp is utilised to keep the insulation of these fittings good. The two hooks are used to suspend the conductors, and as the joints for the branches to the lamps are taken from here, the insulation of these joints is kept good by the warm air rising from the lamp. This fitting has many advantages in rock tunnels, or places where it is necessary to suspend the wires from the roof by insulators, and where there is no timber to attach the wires, lamps, cut-outs, or switches to, and consequently holes have to be bored in the rock, and wooden plugs driven in them. In these tunnels it is generally very expensive to bore holes in the roof, as the rock is very hard, and the required position of the holes is the most difficult for boring, so that the less there are the better. For these reasons the combination fitting was arranged to carry as much as possible. It takes the place of a bracket for two insulators, a support of one switch, two cut-outs and a lampholder; thus one hole suffices for five. The fitting is, moreover, very efficient, as the heat of the lamp is utilised to keep all the necessary parts in connection with the lamp dry, and also the joints and branches from the main wire.

Switches, cut-outs, and lampholders of the above pattern were used for the lighting of the De Beers Mine, and are also being installed in the Kimberley Mine. The De Beers Mine circuit, says the *Colliery Guardian*, was erected by Mr. Drummond over twelve months ago. The mine is lighted 158 hours a week, from Sunday night at five o'clock until the following Sunday morning at seven o'clock. The installation has been

working without a cessation of light during the hours that ground was pulled since its commencement, except on May 20, 1890, when the engine was stopped for 15 minutes to remake one of the joints that had blown out. It has been stopped on two or three occasions during the dinner hour to tighten a belt or repack a gland on the valve spindles, but never during working hours with the exception of the one case mentioned. On three occasions the dynamo was run for 494 hours without a stoppage, and on two occasions for 566 hours, when it was stopped for a public holiday, and without repairs was started again on the same evening, and ran for 422 hours. The installation has been run with only one dynamo and engine, and no accumulators, for about 9,600 hours, and there has never been a fault to hinder the lighting, either from bad insulation or short circuits, nor has the engine or dynamo broken down. No repairs have been necessary or done during this time to the dynamo, engine, or installation, with the exception of cleaning the commutator, tightening the brasses, packing the glands, insulating joints afresh that were originally badly made by the workmen, changing lamps, and the maintenance of the belts and boxing round the wires in the mine. The insulation is tested daily, by placing a voltmeter in circuit between the one main and earth—first one main and then the other. If the insulation gets bad in any place the fault is localised whilst the current is on, and after finding it is repaired. The fuel used for the maintenance of the lights has chiefly been crushed timber and refuse from the mine, and cinders sifted from the different engines about the works. The condenser was arranged to draw water from a swimming-bath and deliver it back again, the bath acting as a cooling pond. The installation is of 100 lamps, but is now being increased to 200; and an installation of 100 lamps is being erected in the Kimberley Mine.

THE JUNIOR ENGINEERING SOCIETY.

PROF. S. P. THOMPSON ON ELECTROMAGNETIC MECHANISMS.

On Friday evening, the 21st inst., the first meeting of the society was held at the Westminster Palace Hotel, when the president, Prof. Silvanus P. Thompson delivered an address on "Electromagnetic Mechanisms."

Prior to the giving of the address, a hearty vote of thanks was accorded to Prof. John Perry, F.R.S., the retiring president, who, in acknowledging the vote, took the opportunity of saying that this was one of the healthiest societies with which he was acquainted.

Prof. Silvanus Thompson having taken the chair, said he believed it was their custom to expect of their president for the year not only that he should give them an address, but that he would write that address out beforehand, print it, and have it ready for distribution. Unfortunately, they had hardly given him sufficient time since they did him the honour of electing him to perform the whole duty of man. Therefore, though he had a portion of his address printed,* there was a portion which was not even yet committed to manuscript, and if a few days elapsed before they had the address in complete form he must beg them to forbear with him.

The topic of his address was "Electromagnetic Mechanisms." To the mechanical engineer the study of the electromagnet presented many interesting problems. By this means power transmitted electrically along a fitting wire produced a mechanical motion. The conditions of that motion constituted in one sense a purely mechanical problem, though the electrical and mechanical conditions under which the power was supplied, and upon which the motion depended, belonged to electrical science. Let them consider at the outset in what an electromagnet consisted. The magnetic portion of it usually comprised two parts. A fixed iron core, bent or straight, and a movable portion of iron commonly called the armature, which two together constituted more or less completely a magnetic circuit. The electrical portion of the electromagnet consisted of a coil or coils of insulated copper wire usually encircling an iron core with numerous convolutions. (Specimens of electromagnets lay on the table and were pointed out to the meeting.) When an electric current was switched in to the copper wire, it produced in the iron core a magnetic action. The magnetising force of the coil was strictly proportional to the current that was furnished in the wire, and to the number of convolutions that the wire made around the magnetic circuit. But the amount of magnetisation induced in the core was not simply proportional to the magnetising force alone. It depended upon the perfection or completeness of the magnetic circuit. If the magnetic circuit constituted by the iron core and its armature and the intervening air gaps was of inordinate length, or if the gaps were considerable, then its reluctance to magnetisation might be so great that very little would be effected in it. The principle of the magnetic circuit was of the first importance as a cue to the behaviour of electromagnets. A second guiding principle was to be found in the tendency which a magnetic circuit always exhibited to perfect itself. That was to say, a magnetic circuit, when subjected to magnetic force, tended, if so arranged that any portion of it could move, so to alter its configuration as to become as compact as possible. If the armature, for example, was movable, and was placed at some little distance away from the influence of the core or coils, it would be mechanically urged into greater proximity, so that core and armature might constitute a closed circuit of iron as nearly as possible. In so doing the armature performed mechanical work. The action of the common horseshoe form of electromagnet in drawing up its armature was an elementary illustration of this principle.

A second form of electromagnet consisted of a tubular coil of copper wire (specimens shown) into the hollow of which an iron plunger was drawn when the current was turned on into the coil. This coil and plunger species of electromagnet possessed many characteristics by which it might be distinguished from the horseshoe or straight core form, but nevertheless the principle applied equally to both. In dealing with the magnetic circuits they must carefully cut themselves off from those mediæval notions of magnetism which haunted the text-books, according to which it was considered as a fluid. The fluids were pure fictions. The existence of a polar surface was a pure accident, the most highly-magnetised part of a magnet being usually that part which showed upon its surface not a trace of magnetic action. It was easy to illustrate what he meant. There (taking it up) was an electromagnet with its armature, and he would take any piece of iron that he happened to have on the table, and on turning on the current, they had this attracted with a moderate force to the piece of iron. His point was that this polar surface which attracted the armature was by no means the most highly-magnetised portion. The bend, or bole, or yoke, of the magnet would not attract the piece of iron at all to any extent, nothing like the extent that the poles at the other end attracted it. This bend or bole was really the most highly-magnetised portion. Indeed, they might have an electromagnet, or, for that matter, a permanent one, having absolutely no external manifestation of magnetism at all. There, for example, was an iron ring covered with copper wire, which, when a current was turned into it, though the iron was highly magnetised internally, would not pick up an iron filing or attract a tintack. There were no poles. The fact was that magnetism was an internal phenomenon, the internal manifestations were the real ones. It was possible to magnetise a steel ring in that way, and afterwards to unwind the copper wires, and for the ring not to show a trace of magnetism. (This was shown by a diagram.) Continuing, Prof. Thompson said that the moment the ring was cut in two, so that the magnetic lines had to come up to the surface and into the air, at once in these gaps in the magnetic circuit the magnetic virtues were revealed. It was when the magnetic lines got out of the iron into air that they obtained the action commonly called magnetic. The pole or polar region of a magnet was merely another way of stating that at that part of the surface the magnetic lines emerged from the interior into the air. The proper modern mode of regarding magnetic phenomena was to consider the various metals—iron, steel, etc.—as being in various degrees conductors of magnetic lines. These being, as it were, stream-lines in the magnetic medium, which were conveniently taken to represent by their number and direction the quantity and direction of the fluxes of internal magnetisation. He used the word flux there rather than current, in order that they might not confuse the magnetic action running through the circuit, with the electric current circling outside it, which produced the magnetic force. Wherever there was a gap in the magnetic circuit between iron and iron, there was a magnetic stress urging the configuration so to change as to close up the gap. This stress urged the armature of the electromagnet towards the iron core. They might call it an attraction if they preferred that way of putting it, only let them beware, for this attraction did not vary as the inverse square of the distance. It depended upon other things, such as the quality of the iron behind, the length and cross-section of the iron behind, and not simply upon the distance of the surfaces apart. The stress of the two surfaces depended solely upon the strength of the magnetic flux in the intervening medium, which in turn depended upon the reluctance. He might pause here to make a little digression. He had said that they took the number of the magnetic lines to represent the degree of magnetisation internally. They assigned to each degree of internal magnetisation a number. Having defined what they called one magnetic line, they were able to specify degrees of magnetisation. It was practicably impossible with the very best wrought iron, under ordinary circumstances, to force more than 130,000 magnetic lines per square inch into it. And the stress in the intervening medium in the gap depended, as he had just remarked, upon the square of the number of magnetic lines. At one time there was a notion that these magnetic lines might be regarded as though they were invisible elastic threads. If that were true, they ought to have the greater pull between the two surfaces when the gap was widened, whereas the contrary was the fact. They ought also to find that the pull between the two surfaces was proportional to the number of magnetic lines across the gap, but it was proportional to their square. The space traversed by the magnetic lines was called the magnetic field. (Prof. Thompson then gave a history of the invention of the electromagnet, which will be found in his Cantor lectures, and need not be given here.)

(To be continued.)

* This was not forthcoming at the meeting, and this report is from our own notes of what Prof. Thompson said.

WIRES DOWN.—Hundreds of telegraph wires were brought down in Dublin on Thursday morning by snow.

THE

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

PROF. S. THOMPSON AT THE JUNIOR ENGINEERS.

It is a great pleasure to listen to Prof. S. Thompson at any time and on any subject; but the pleasure is tempered with something else when open windows pour down cold air upon heated people in a heated room. The Junior Engineering Society should look to this.

Prof. Thompson is one of those men who hold a somewhat unique position, in that he never risks addressing an audience except upon a subject with which he is thoroughly conversant. On Friday last he delivered the presidential address to the Junior Engineers, the subject being "Electromagnetic Mechanisms." The subject matter was very similar to that of his Cantor lectures, now being published in the technical papers, and just issued in a complete form by the Society of Arts. Our admiration for Prof. Thompson's matter and method is tinged with regret that upon certain points we are bound to differ with his conclusions. Having made up his mind that the old text-books are faulty, it is a pity that he cannot break away from them to a greater extent. In any general condemnation of books, we distinctly reserve such condemnation for those books written by schoolmasters for schoolmasters and for examination purposes. With hardly an exception, these books are mere scholastic twaddle, most of them without a single redeeming feature—unless assisting to "cram for an exam." be such a feature. Other books usually not written by schoolmasters, and filled with heterodox views, ultimately prove to contain the leaven that leavens the whole lump of public opinion.

To writers and teachers outside the scholastic pale, credit for anything is seldom given. For them as for the unpatriotic, we might parody Scott and say

> "Go, mark them well,
> For them no minstrel raptures swell."

The last 10 years has opened the eyes and widened the views of those we are accustomed to accept without demur as our teachers *par excellence*, but in matters electrical, beside the names of Thomson and Maxwell, we would place those of Sprague, FitzGerald, and Webb. The two former have opened the eyes of the mathematicians, the three latter by their writings and teaching have opened the eyes of the more practical, and laid a foundation for the better reception of the "modern views" as taught now. Most of the views now looked upon as "modern," that is, accepted by professordom during the past four or five years, were taught by these men 15, 20, or 25 years ago. Bluntly—Green's mathematics were valueless for half a century; they were outside the comprehension of the multitude. And it is ever thus. The men who revel in transcendentalism are of less value in the world's progress than men who can talk and be understood. We are

afraid that the work of the men who endeavour to be understood does not impress itself upon the professorial mind like that of men who write and teach, and are understood only upon trust. There are a few men who can translate mathematical language, there are many men who can translate physical language. Prof. Thompson seems sometimes undecided as to which language to adopt. This indecision invites criticism upon one point especially. No doubt we shall be told that we are altogether wrong in our explanation, but this we are used to, as we are accustomed to see views expressed in these pages adopted without thanks by those who in the first instance ridicule them. We are living to see "conductive," "inductive," and "magnetic" circuits a common way of speaking, yet as Shakespeare says, "Oh, the pity of it" that it was not adopted years ago.

In the address there are two points which may be referred to here. One of these is that action, pull, or whatever you like to term it, as Prof. Thompson puts it, involves the "square of the flux." He rather challenged anyone to explain it other than in the way he proposed. He well knows that we contend that this "square of the flux" view is pure moonshine. The phenomenon may be as he would describe it, but his explanation is no more satisfactory than others to our mind. He pooh-poohed the elastic band theory or elastic line of force theory, but that is better than a "square of flux" theory, though both may be so translated as to come to the same thing. Taking the very useful convention of "line of force," surely we may, without difficulty, assume that the pull of any line of force is inversely proportional to its length—that is, the pull of a line of force from the same source acting on a point half the distance is double what it would be when acting upon a point at the whole distance. Again, halving the distance generally means halving the resistance, and the impressed force generating one line of force at the whole distance or the whole resistance will generate two at half the distance or half the resistance. Thus we get two lines, each acting over the half distance with double force, the total action or pull being four times the original pull. To our mind the physical conception of double number acting with double force at half distance is simpler than any abstract conception of squaring the pull. Certainly the result is the same, and it gives a reason for this result, which the "square of the flux" does not. The difference between Prof. Thompson and ourselves is that he prefers a purely abstract "formula" of which no physical conception is possible, while we prefer a workable physical conception to which the formula can be applied. A distinction without a difference we hear some people say, which shows their ignorance.

The other point to which we would refer here is the introduction of another new term. Prof. Thompson would introduce the compound adjective, and dub electrical engineers electromagnetic engineers. He implies that the study of electricity does not include the study of magnetism, and that the past-master of electrical science knows nothing about electromagnetism. Now, if there is one thing certain, it is that electricity, so called, and magnetism are not distinct, and that the study of the one necessarily involves the study of the other. You cannot by any possible means generate electrical without at the same time generating magnetic phenomena. The attempt to introduce a new designation is uncalled for, and founded upon ideas that are misleading.

DEPTFORD.

We are happy to be able to announce that the lighting from the Deptford station, stopped by the recent fire at the Grosvenor, was resumed on Wednesday last on all the circuits, except the St. James's. The Piccadilly and the Pall Mall circuits are those supplying the most important clubs and public buildings to the extent of some 30,000 lamps. The other circuit is expected to be working to-day or to-morrow, and the whole lighting will thus be taken on again. It would have been possible and easy to resume the next day had it not been for the unfortunate destruction or damage of the transformers. These have been replaced or repaired, the men working night and day, and a fireproof chamber provided, a thing which would have been done earlier had there been granted a couple of days or even one whole day's complete cessation of lighting. If there seems to be one lesson to be taken to heart over this occurrence, it is that, in spite of the objurgations of the consumers, it is, and must be definitely considered, far the best, even from the point of view of the consumers themselves, to cease work for a day on an occasion in the critical point of the history of an important installation such as this was, rather than to take the extreme risk of what might prove a week's enforced stoppage.

THE BOARD OF TRADE.

Elsewhere will be found the text of two letters sent under the combined action of several companies to the President of the Board of Trade. The contents of these letters are fully explanatory of the objects sought by the petitioners. We are quite sure the advisers of the Board of Trade cannot at the present time draw up hard and fast rules, which, like the laws of the "Medes and Persians," are unalterable, but they will be compelled to keep an open mind, to hear objections from members of the industry, to witness experiments, and to relax regulations when objectionable and unwarranted by

the facts of the case. In our opinion the Board of Trade occupies the position of an unbiassed party, whose work is to guard against the general safety of the public being tampered with, and to obviate, as far as possible, the inconveniences arising to the public by the introduction of a new system of lighting and transmission of power. If, then, the regulations of the Board of Trade are such as not only to ensure safety, but to ensure it at the expense of stopping the whole business, when it can be proved that such regulations go far beyond what is required, such regulations must be amended. There should be little or no dictation of what is safe, expedient, or convenient, but the supervision exercised should be such as to permit condemnation of that which cannot be shown or proved to be safe. We commend these letters to our readers, and trust they will receive the sanction of all engaged in the industry.

ELECTRIC FOG SIGNALLING.

The enormous advantages early conferred on railway management by the invention of the electric telegraph seem altogether to lose their efficiency whenever the miserable fog, which is such a constant visitor to London, makes its appearance. Then all arrangements are abrogated, spare men are sent for in hot haste and are posted like ghostly sentries by glowing fires along the route, waving flags, and, almost at risk of life, placing detonators on the rail which explode with irritating frequency to the fright of the female passengers, making the scene far more like a skirmish of warfare amidst smoke and deafening reports than scientific suburban traffic in the nineteenth century; while, if to ordinary business men the unwonted explosions are not so disquieting, yet the almost inevitable and constant stoppages are most annoying, often the cause of missing of important engagements, or even of considerable monetary loss. It is evident that whichever suburban line could assure its passengers that, fog or no fog, trains could be properly signalled and would not be delayed, this line would be at a great advantage over its competitors. But aside from this feeling of rivalry, the enormous expense to all railways attendant on a really thick fog, the delay and derangement, to say nothing of a more than possible accident, all call aloud for some other means than the present semi-barbarous method of scouts and explosives. We are not aware, although the demand has been before railway men year after year, that electricity has ever been seriously called upon to tackle this question, that of plain signalling, even in the deepest fog; but if the engine driver were absolutely sure of his signals, and the signal man were also sure of the passing of the train, there is no reason why trains should not run as fast and as surely in the deepest fog as they now do at dead of night. There is nothing impossible about the application of electricity to such a purpose, and the method invented and brought forward by Mr. W. Andrews and Mr. Arthur Guy, which has been fitted up on the railway beyond King's Cross, is worthy of the very serious investigation of the railway authorities. By means of a metal rail at a certain distance from the signals, a sliding contact on the engine completes an electric circuit, and a miniature semaphore is actuated to "danger" or "line clear" up or down, according to the direction of the current. The safety of the system consists in the fact that the current is always on, one way or the other, the direction depending on the position of the signals. We understand that the Board of Trade have inspected the invention, and consider it the best that has yet attempted to deal with the fog difficulty, and have gone so far as strongly to advise its adoption by the railway companies.

CORRESPONDENCE.

BARROW-IN-FURNESS.

To the Editor of The Electrical Engineer.

Sir,—Your issue of to-day has a notice to the effect that the Corporation of Barrow have invited customers for the electric light. As a recipient of one of these invitation circulars, I desire to ask the opinion of your readers about the statements therein, it having occurred to me that there is something rather misleading about the costs. Will someone please give their experience of public lighting, and say if these extra costs are also incurred at other places, and if the life of a lamp is so short. Circular herewith.—Yours, etc.,

Electric Light.

November 22, 1890.

"Town Clerk's Office, Town Hall,
"Barrow-in-Furness, Oct. 24, 1890.

"Sir,—The Corporation have again under their consideration the question of the supply within the borough of the electric light for public and private purposes.

"To enable them to form a conclusion on the subject, they desire to know what support is likely to be received from private consumers in the event of the Corporation deciding either to supply the light themselves, or to sanction its being supplied by a company.

"With this object you are requested to fill up the enclosed form.

"It is estimated that the price to be charged for the electric light will be somewhat in excess of the cost of gas for the same amount of light (one 16-candle electric lamp being equal to one ordinary gas-burner). The exact amount of this excess cannot be stated with any certainty, but it is computed to be from 20 to 100 per cent., according to the system adopted and the extent to which the light is taken.

"Against this increased cost must be set the advantages of the electric light, which include absence of heat, purity of atmosphere, cleanliness, and the avoidance of injury to decorations, furniture, and books, etc.

"The consumer would have to bear (as he at present does as regards gas) the cost of the connection from the main, and for the fittings, which cost is estimated at 20s. to 25s. per lamp according to the number of lights used.

"There would also be a meter rent of about 20s. a year for every Board of Trade unit, equal to 17 lamps of 16 candles each, and the consumer would of course have to renew his lamps at his own cost—the average life of a lamp is about 900 hours, the cost of lamps varies from 3s. to 4s. each.—By order,

"C. F. Preston, town clerk."

NOTES ON THE CHEMISTRY OF SECONDARY CELLS.*

BY PROF. W. E. AYRTON, VICE-PRESIDENT; C. G. LAMB, B.SC., AND E. W. SMITH, ASSOCIATES.

I.

In our paper on "The Working Efficiency of Secondary Cells," read at the meeting of this Institution in Edinburgh in July, it was stated that, "In spite of accumulators with pasted plates having been in use now for nine years, the chemical action that takes place during the different stages of the charge and discharge has only been conjectured, and, odd as it seems, no decisive experiment appears to have been made to settle this much-debated question. Various analyses have been made by different chemists of salts of lead acted on in certain ways with sulphuric acid, but apparently not of actual accumulator plates in action. We are therefore now, with the assistance of Mr. Robertson, making a complete investigation of the chemical state of the plugs of both the positive and negative plates at all stages of the charges and discharge of an 1888 E.P.S. type of accumulator in good condition." The present paper contains an account of the results thus obtained.

Fig. 1.

The cell selected to remove the plugs from had the same size as the cells employed in the investigations described in the previous communication, and was one of the batch of 50 purchased for the Central Institution about the middle of 1888. Since it first came into our possession it had never been overcharged, never been left discharged, nor permitted to send more than the maximum current allowed by the makers for cells of this size—viz., 10 amperes—and consequently, at the beginning of the present investigation in June of this year, this cell was in excellent condition.

Fig. 2.

First, the cell was several times charged with a current of nine amperes, and discharged with a current of 10, without stopping day or night, so as to bring it into what we have called its steady "working" state. The dotted curves, Figs. 1 and 2, show the large charge and discharge obtained on June 28th. During the next charge, indicated by the continuous curve, Fig. 1, plugs were removed from both the positive and the negative plates at the points marked A, B, C, and D, when the terminal P.D. of the cell was 2·134, 2·1, 2·234, and 2·4 volts respectively. In order to remove the plugs from the positive plates, these plates were bodily removed out of the liquid, but, to prevent oxidation, the negative plates were left in the liquid, and the plugs removed in a way that will be described later on. The time occupied in removing the plugs from the two sets of plates occupied about 15 to 20 minutes on each occasion. Immediately after the removal of the plugs the positive plates were put back in position in the cell, the resistance in the circuit rapidly adjusted, if necessary, to make the charging current exactly nine amperes, and the time variation of the P.D. at the terminals of the cell noted. The interval that elapsed while the current was broken is not shown on the curve; that is to say, the P.D. observed immediately after replacing the positive plates in the liquid and closing the circuit is plotted directly under the P.D. that was observed just before the circuit was broken, prior to the removal of the positive plates from the liquid.

We were afraid that the bodily withdrawal of the positive plates out of the liquid, combined with the removal of the plugs, on the several occasions, would produce so great a change in the conditions of the cell as to render the P.D. curve quite discontinuous. It was, therefore, as interesting as it was unexpected to find that the terminal P.D., on restarting the normal charging current of nine amperes, rapidly acquired the value it had before the withdrawal of the plates; so that, with the exception of the rapid rise of the P.D. on restarting the charging current, the P.D. curve obtained on June 29 was almost the same as the P.D. curve obtained on charging the previous day.

After the cell had been charged until the terminal P.D. reached 2·4 volts, it was immediately discharged with a perfectly constant current of 10 amperes, and, as it was anticipated that the removal of the plugs would spoil the cell, it was allowed to discharge far below the normal limit. In previous discharges (the last one of which is shown by the dotted line, Fig. 2), the discharge was stopped when the terminal P.D. fell to 1·85 volts. But in the discharge on June 30, when the plugs were removed the discharge current was kept at 10 amperes, by using auxiliary cells, until the E.M.F. of the test cell fell to nought, and even reversed. Plugs were removed from both the positive and the negative plates when the terminal P.D. was 2, 1·95, 1·85, 0·6, and nought volts, as indicated by the points, A′, B′, C′, D′, and E′. The recovery of the E.M.F. on breaking the circuit was very marked, especially near the end of the discharge.

II.—Method of Obtaining Samples of the Plugs.

On the first removal of plugs corresponding with the point A, Fig. 1, a curved pointed glass rod was used, as shown in Fig. 3, with the idea of prising out the plugs, but by this method only the surface of the positive plugs could be removed, as they were much too hard to be loosened in this way. Indeed, one of the most striking things noticed in this investigation was the firm way in which the plugs were held in the plates of an E.P.S. cell that had been carefully used for two years. Before the next attempt was made to remove plugs corresponding with the point B, Fig. 1, a straight piece of glass rod was pointed, and mounted in a wooden handle. This glass chisel was used to pierce and loosen the positive plugs, which were then driven bodily out of the grid by means of a hard wooden punch cut square to fit the holes in the grid, and which was tapped with a small mallet. The plugs on being driven out of the grid were caught in a long wooden scoop (shaped so that it could be just slipped in between the plates), and then washed by Mr. Robertson into wide-mouthed bottles containing 300 or 400 c.c. of distilled water. As soon as the water cleared it was decanted off and fresh added.

Fig. 3.

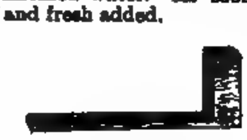

Fig. 4.

As several glass chisels were broken, and the wooden punches worn down in the removal of the plugs, the method had the disadvantage of mixing with the specimens to be analysed splinters of glass and wood, which were found difficult to remove afterwards. On the other hand, the method had the advantage of enabling specimens of the positive plugs to be removed in a comparatively short time on each occasion from the top, the middle, and the bottom of the plates.

As the negative plates were never removed from the acid, the only way to remove the plugs was by working them loose under the liquid by means of long curved glass rods pointed at the end, and by catching the plugs in a narrow wooden scoop with a long handle, as shown in Fig. 4. It was possible to use this method throughout for the removal of the negative plugs, as they were softer and more easily removable than the positive ones. The scoop held sufficient liquid to enable the negative plugs to be dropped into wide-necked bottles containing water without the plugs being even momentarily exposed to the air. The water in these bottles Mr. Robertson had washed free from dissolved oxygen by previously bubbling hydrogen through it for a considerable time. After the negative plugs had been put into the bottles the water was gradually decanted off from time to time, and fresh added until the liquid in the bottle was quite free from acid.

Both in the case of the positives and the negatives the top

* Paper read before the Institution of Electrical Engineers.

samples were removed from the corner of the plates nearest the lug, and the bottom samples from the corner diametrically opposite, so as to obtain evidence, if possible, of any difference of current density which might exist at different parts of the plates in charging and discharging.

The plugs from the top, the middle, and the bottom of each set of plates were at each of the removals of plugs put into six separate bottles, and, to avoid the possibility of error in their subsequent identification, there was noted on the label of each the character of the plates, and the position on them from which the plugs were removed, the time, the P.D., and the specific gravity of the liquid in the cell.

III.—Appearance of Plates at Removals of Plugs.

The following notes were made by Mr. Robertson and ourselves at the successive removals of the plugs:

Charging.

Point A on Curve 1. Terminal P.D., 2·134 volts. Specific Gravity of Liquid, 1·178.

Positive Plates.	Negative Plates.
The upper part of the plates had a greyish-brown colour, and presented the appearance of being coated with a very thin film of white sulphate. The lower part of the plates was of a reddish-brown colour. The plugs at the top were hard, while those at the bottom were quite soft.	The plugs at the top were the softest.

Point B on Curve 1. Terminal P.D., 2·2 volts. Specific Gravity of Liquid, 1·198.

The plates had entirely lost their whitish appearance, and showed a uniform reddish-brown colour, darker than the previous colour of the bottom of the plates.	The plugs both at the top and at the bottom harder than before, those at the top having hardened more than those at the bottom.

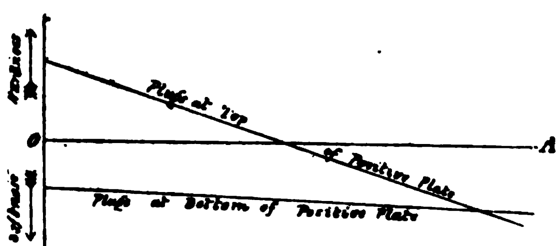

Fig. 5.

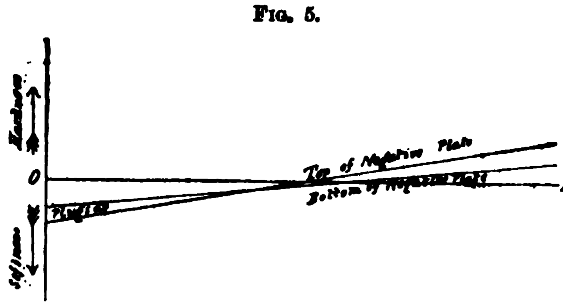

Fig. 6.

Point C on Curve 1. Terminal P.D., 2·234 volts. Specific Gravity of Liquid, 1·201.

The previous charges increased in amount.	The previous charges increased in amount.

Point D on Curve 1. Terminal P.D., 2·4 volts. Specific Gravity of Liquid, 1·206.

The plates had the rich deep brown colour of lead peroxide, except where they were covered with the ebonite separators. There the colour was lighter. The plugs at the top were slightly the softest, while those at the bottom were much the same as at the beginning.	The plugs had a brilliant metallic lustre, and looked quite silvery when first removed from the plates. The plugs at the top were now the hardest.

Discharging.

Point A' on Curve 2. Terminal P.D., 1·998 volts. Specific Gravity of Liquid, 1·205.

Positive Plates.	Negative Plates.
The plugs at the top were harder than those at the bottom.	The plugs had the brilliant metallic lustre observed at the end of the charging.

Point C' on Curve 2. Terminal P.D., 1·850 volts. Specific Gravity of Liquid, 1·180.

The plugs had become much harder.	The plates had become decidedly white, and the plugs were white right through.

Point D' on Curve 2. Terminal P.D., 0·6 volt. Specific Gravity of Liquid, 1·175.

The plugs had become extremely hard, especially at the bottom.	The plugs were somewhat softer.

Point E' on Curve 2. Terminal P.D., 0 volt. Specific Gravity of Liquid, 1·172.

The plugs had become so hard that they splintered and bits flew about on trying to remove them.	——

The bubbling of gas from the negative plates ceased when the terminal P.D. on discharging fell to 1·85 volts (point C' on curve 2), and it began again when the terminal P.D. fell to somewhere below zero.

The preceding figures (5 and 6) give an idea of the way in which we found the hardness of the top and bottom plugs of the positive and the negative plates respectively to vary during a normal charge. The figures are not drawn to scale, as we had no standard of hardness beyond our sensations, hence the figures only profess to be qualitative sketches from which mental pictures can be obtained. Distance measured upways from O A indicates roughly the degree of hardness; distance measured downwards, the degree of softness.

(*To be continued*).

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

Lecture II.

(*Continued from page 453.*)

The results of Prof. Ewing's are further represented by the curves of magnetism drawn in Fig. 48. When the faces of a cut were carefully surfaced up to true planes, the disadvantageous

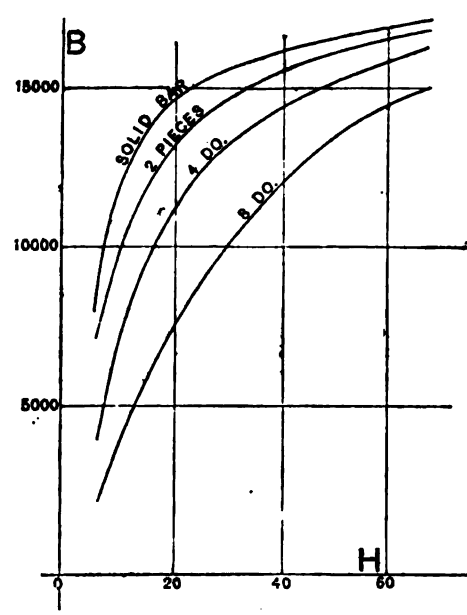

Fig. 48.—Ewing's Curves for Effect of Joints.

effect of the cut was reduced considerably, and under the application of a heavy external pressure, almost vanished.

I have several times referred to experimental results obtained in past years, principally by German and French workers, buried in obscurity in the pages of foreign scientific journals. Too often, indeed, the scattered papers of the German physicists are rendered worthless or unintelligible by reason of the omission of some of the data of the experiments. They give no measurements, perhaps, of their currents, or they used an uncalibrated galvanometer, or they do not say how many windings they were using in their coils; or perhaps they give their results in some obsolete phraseology. They are extremely addicted to informing you about the "magnetic moments" of their magnets. Now, the magnetic moment of an electromagnet is the one thing that one never wants to know. Indeed the magnetic moment of a magnet of any kind is a useless piece of information, except in the case of bar magnets of hard steel that are to be used in the determination of the horizontal component of the earth's magnetic force. What one does want to know about an electromagnet is the number of magnetic lines flowing through its circuit, and this the older researches rarely afford the means of ascertaining. Nevertheless, there are some investigations worthy of study to which time will now only permit me very briefly to allude. These are the researches of Dub on the effect of thickness of armatures, and those of Nicklès and of Du Moncel on the lengths of armatures. Also those of Nicklès on the effect of width between the two limbs of the horseshoe electromagnet.

I can only now describe some experiments of Von Feilitzsch upon

* Cantor lectures, delivered before the Society of Arts.

—	For centimetre measure.	For inch measure.
1. Armature	$\frac{l}{A_1 \mu_1}$	$\frac{l''_1}{A''_1 \mu_1} \times 0{\cdot}3132$
2. The gaps	$2\frac{l_2}{A_2}$	$2\frac{l''_2}{A''_2} \times 0{\cdot}3132$
3. Magnet core	$\frac{l_3}{A_3 \mu_3}$	$\frac{l''_3}{A''_3 \mu_3} \times 0{\cdot}3132$

To Calculate the Ampere-turns of Magnetising Power requisite to force the Desired Magnetic Flux through the Reluctances of the Magnetic Circuit.

(*a*) *If Dimensions are given in Centimetres* the rule is

Ampere-turns = the magnetic flux, multiplied by the magnetic reluctance of the circuit, divided by $\frac{4}{10}$ of π ($=1{\cdot}2566$).

Or, in detail, the three separate amounts of ampere-turns required for three principal magnetic reluctances are explained as follows:

Ampere-turns required to drive N lines through iron of armature .... $\Big\} = N \times \frac{l_1}{A_1 \mu_1} \div \frac{4\pi}{10}$,

Ampere-turns required to drive N lines through the two gaps .... $\Big\} = N \times \frac{2\, l_2}{A_2} \div \frac{4\pi}{10}$,

Ampere-turns required to drive v N lines through the iron of magnet core .... $\Big\} = v\, N \times \frac{l_3}{A_3 \mu_3} \div \frac{4\pi}{10}$,

And, adding up

$$\text{Total ampere-turns required} \;\ldots = \frac{10}{4\pi} N \left\{ \frac{l_1}{A_1 \mu_1} + \frac{2\, l_2}{A_2} + \frac{v\, l_3}{A_3 \mu_3} \right\}.$$

(*b*) *If Dimensions are given in Inches*, the rule is: Ampere-turns = magnetic flux multiplied by the magnetic reluctance of the circuit. Or, in detail:

Ampere-turns required to drive N lines through iron of armature .... $\Big\} = N \times \frac{l''_1}{A''_1 \mu_1} \times 0{\cdot}3132$,

Ampere-turns required to drive N lines through two gaps .... $\Big\} = N \times \frac{2\, l''_2}{A''_2} \times 0{\cdot}3132$,

Ampere-turns required to drive v N lines through iron core of magnet.............. $\Big\} = v\, N \times \frac{l''_3}{A''_3 \mu_3} \times 0{\cdot}3132$

And, adding up:

$$\text{Total ampere-turns required} = 0{\cdot}3132\, N \left\{ \frac{l''_1}{A''_1 \mu_1} + \frac{2\, l''_2}{A''_2} + \frac{v\, l''_3}{A''_3 \mu_3} \right\}.$$

It will be noted that here v, the coefficient of allowance for leakage, has been introduced. This has to be calculated as shown later. In the meantime, it may be pointed out that, in designing electromagnets for any case where v is approximately known beforehand, the calculation may be simplified by taking the sectional area of the magnet core greater than that of the armature in the same proportion. For example, if it were known that the waste lines that leak were going to be equal in number to those that are usefully employed in the armature (here $v=2$), the iron of the cross might be made of double the section of that of the armature. In this case μ_3 will approximately equal μ_1.

To Calculate the Coefficient of Allowance for Leakage, v.

v = total magnetic flux generated in magnet core ÷ useful magnetic flux through armature. The respective useful and waste magnetic fluxes are proportional to the permeances along their respective paths. Permeance, or magnetic conductance, is the reciprocal of the reluctance, or magnetic resistance. Call useful permeance through armature and gaps u, and the waste permeance in the stray field w; then

$$v = \frac{u + w}{u},$$

w may be estimated by the Table VIII. given above, or other leakage rules, but should be divided by two, as the average difference of magnetic potential over the leakage surface is only about half that at the ends of the poles.

Rules for Estimating Magnetic Leakage.

(I. to III. Adapted from Prof. Forbes's rules.)

Prop. I. Permeance between two parallel areas facing one another.—Let areas be A_1'' and A_2'' square inches, and distance apart d'' inches, then:

$$\text{Permeance} = 3{\cdot}193 \times \tfrac{1}{2}\,(A''_1 \times A''_2) \div d''.$$

Prop. II. Permeance between two equal adjacent rectangular areas lying in one plane.—Assuming lines of flow to be semicircles, and that distances d''_1 and d''_2 between their nearest and furthest edges respectively are given, also a their width along the parallel edge:

$$\text{Permeance} = 2{\cdot}274 \times a'' \times \log_{10} \frac{d_2''}{d_1''}.$$

Prop. III. Permeance between two equal parallel rectangular areas lying in one plane at some distance apart.—Assume lines of leakage to be quadrants joined by straight lines.

$$\text{Permeance} = 2{\cdot}274 \times a'' \times \log_{10} \left\{ 1 + \frac{\pi (d''_2 - d''_1)}{d''_1} \right\}.$$

Prop. IV. Permeance between two equal areas at right angles to one another.—Permeance (if air angle is 90deg.) = double the respective value calculated by II. or III.

Permeance (if angle is 270deg.) = $1\frac{1}{3}$ times the respective value calculated by II.

If measures are given in centimetres these rules become the following:

$$\text{I.}\ \tfrac{1}{2}\,(A_1 + A_2) \div d;$$

$$\text{II.}\ \frac{a}{\pi} \log_e \frac{d_2}{d_1};$$

$$\text{III.}\ \frac{a}{\pi} \log_e \left(1 + \frac{\pi (d_2 - d_1)}{d_1} \right).$$

Prop. V. Permeance between two parallel cylinders of indefinite length.—The formula for the reluctance is given above; the permeance is the reciprocal of it. Calculations are simplified by reference to Table VIII.

LECTURE III.—Special Designs.

In continuation of my lecture of last week, I have to make a few remarks before entering upon the consideration of special forms of magnets, which was to form the entire topic of to-night's lecture. I have not quite finished the experimental results which related to the performance of magnets under various conditions. I had already pointed out that where you require a magnet simply for holding on to its armature, common-sense (in the form of our simplest formula) dictated that the circuit of iron should be as short as was compatible with getting the required amount of winding upon it. That at once brings us to the question of the difference in the performance of long magnets and short ones. Last week we treated that topic as far as this, that if you require your magnet to attract over any range across an air space, you required a sufficient amount of exciting power in the circulation of electric current to force the magnetic lines across that resistance, and therefore you required length of core in order to get the required coil wound upon the magnetic circuit. But there is one other way in which the difference of behaviour between long and short magnets—I am speaking of horseshoe shapes—comes into play. So far back as 1840, Ritchie found that it was more difficult to magnetise steel magnets (using for that purpose electromagnets to stroke them with) if those electromagnets were short than if they were long. He was, of course, comparing magnets which had the same tractive power, that is to say, presumably had the same section of iron magnetised up to the same degree of magnetisation. This difference between long and short cores is obviously to be explained on the same principle as the greater projecting power of the long-legged magnets. In order to force magnetism not only through an iron arch but through whatever is beyond, which has a lesser permeability for magnetism, whether it be an air gap or an arch of hard steel destined to retain some of its magnetism, you require magneto-motive force enough to drive the magnetism through that resisting medium; and, therefore, you must have turns of wire; that implies that you must have length of leg on which to wind those turns. Ritchie also found that the amount of magnetism remaining behind in the soft iron arch, after turning off the current, at the first removal of the armature, was a little greater with long than with short magnets; and, indeed, it is what we should expect now, knowing the properties of iron, that long pieces, however soft, retains a little more—have a little more memory, as it were, of having been magnetised—than short pieces. Later on I shall have specially to draw your attention to the behaviour of short pieces of iron which have no magnetic memory.

Winding of the Copper.

I now take up the question of winding the copper wire upon the electromagnet. How are we to determine beforehand the amount of wire required, and the proper gauge of wire to employ?

The first stage of such a determination is already accomplished; we are already in possession of the formulæ for reckoning out the number of ampere-turns of excitation required in any given case. It remains to show how from this to calculate the amount of bobbin space, and the quantity of wire to fill it. Bear in mind that a current of 10 amperes (*i.e.*, as strong as that used for a big arc light) flowing once around the iron, produces exactly the same effect magnetically as a current of one ampere flowing around 10 times, or as a current of only one-hundredth part of an ampere flowing around a thousand times. In telegraphic work the currents ordinarily used in the lines are quite small, usually from five to twenty thousandths of an ampere; hence in such cases the wire that is wound on need only be a thin one, but it must have a great many turns. Because it is thin and has a great many turns, and is consequently a long wire, it will offer a considerable resistance. That is no advantage, but does not necessarily imply any greater waste of energy than if a thicker coil of fewer turns were used with a correspondingly larger current. Consider a very simple case. Suppose a bobbin is already filled with a certain number of turns of wire, say 100, of a size large enough to carry one ampere, without over-heating. It will offer a certain resistance, it will waste a certain amount of the energy of the current, and it will have a certain magnetising power. Now suppose this bobbin to be rewound with a wire of half the diameter; what will the result be? If the wire is half the diameter it will have one quarter the sectional area, and the bobbin will hold four times as many turns (assuming insulating materials to occupy the same percentage of the available volume). The current which such a wire will carry will be one-fourth as great. The coil will offer sixteen times as much resistance, being four times as long and of one-fourth the cross-section as the other wire. But the waste of energy will be the same, being proportional to the resistance and to the square of the current; for $16 \times \frac{1}{16} = 1$. Consequently the heating effect will be the same. Also the magnetising power will be the same, for though the current is only one-quarter of an ampere, it flows around 400 turns; the

ampere-turns are 100, the same as before. The same argument would hold good with any other numerical instance that might be given. It therefore does not matter in the least to the magnetic behaviour of the electromagnet whether it is wound with thick wire or thin wire, provided the thickness of the wire corresponds to the current it has to carry, so that the same number of watts of power are spent in heating it. For a coil wound on a bobbin of given volume the magnetising power is the same for the same heat waste. But the heat waste increases in a greater ratio than the magnetising power, if the current in a given coil is increased, for the heat is proportional to the square of the current, and the magnetising power is simply proportional to the current. Hence, it is the heating effect which in reality determines the winding of the wire. We must—assuming that the current will have a certain strength—allow enough volume to admit of our getting the requisite number of ampere-turns without overheating. A good way is to assume a current of one ampere while one calculates the coil. Having done this, the same volume holds good for any other gauge of wire appropriate to any other current. The terms "long-coil" magnet and "short-coil" magnet are appropriate for those electromagnets which have respectively many turns of thin wire and few turns of thick wire. These terms are preferable to "high-resistance" and "low-resistance," sometimes used to designate the two classes of windings, because, as I have just shown, the resistance of a coil has in itself nothing to do with its magnetising power. Given the volume occupied by the copper, then for any current density (say, for example, a current density of 2,000 amperes per square inch of cross-section of the copper), the magnetising power of the coil will be the same for all different gauges of wire. The specific conductivity of the copper itself is of importance, for the better the conductivity the less the heat waste per cubic inch of winding. High-conductivity copper is, therefore, to be preferred in every case.

Now, the heat which is thus generated by the current of electricity raises the temperature of the coil (and of the core), and it begins to emit heat from its surface. It may be taken as a sufficient approximation that a single square inch of surface, warmed 1deg. F. above the surrounding air, will steadily emit heat at the rate of $\frac{1}{225}$ of a watt; or, if there is provided only enough surface to allow of a steady emission of heat at the rate of one watt* per square inch of surface, the temperature of that surface will rise to about 225deg. F. above the temperature of the surrounding air. This number is determined by the average emissivity of such substances as cotton, silk, varnish, and other materials of which the surfaces of coils are usually composed.

In the specifications for dynamo machines it is usual to lay down a condition that the coils shall not heat more than a certain number of degrees warmer than the air. With electromagnets it is a safe rule to say that no electromagnet ought ever to heat up to a temperature more than 100deg. F. above the surrounding air. In many cases it is quite safe to exceed this limit.

The resistance of the insulated copper wire on a bobbin may be approximately calculated by the following rule. If d is the diameter of the naked wire (in mils), and D is the diameter (in mils) of the wire when covered, then the resistance per cubic inch of the coil will be—

$$\text{Ohms per cubic inch} = \frac{960{,}700}{D^2 \times d^2}.$$

We are, therefore, able to construct a wire-gauge and amperage table which will enable us to calculate readily the degree to which a given coil will warm when traversed by a given current, or, conversely, what volume of coil will be needed to provide the requisite circulation of current without warming beyond any prescribed excess.

Accordingly, I here give a *Wire-Gauge and Amperage Table*, which we have been using for some time at the Finsbury Technical College. It was calculated out under my instructions by one of the demonstrators of the college, Mr. Eustace Thomas, to whom I am indebted for the great care bestowed upon the calculations.

For many purposes—such as for use in telegraphs and electric bells—smaller wires than any of those mentioned in the table are required. The table is, in fact, intended for use in calculating magnets in larger engineering work.

A rough and ready rule sometimes given for the size of wire is to allow $\frac{1}{1000}$ square inch per ampere. This is an absurd rule, however, as the figures in the table show. Under the heading 1,000 amperes to square inch, it appears that if a No. 18 S.W.G. wire is used, it will at that rate carry 1·81 amperes; that if there is only one layer of wire it will only warm up to 4·64deg. F., consequently one might wind layer after layer to a depth of 3·3in. without getting up to the limit of allowing one square inch per watt for the emission of heat. In very few cases does one want to wind a coil so thick as 3·3in. For very few electromagnets is it needful that the layer of coil should exceed ½in. in thickness; and if the layer is going to be only ½in. thick, or about one-seventh of the 3·3, one may use a current density $\sqrt{7}$ times as great as 1,000 amperes per square inch without exceeding the limit of safe working. Indeed, with coils only ½in. thick, one may safely employ a current density of 3,000 amperes per square inch, owing to the assistance which the core gives for the dissipation and emission of heat.

Suppose, then, we have designed a horseshoe magnet with a core 1in. in diameter, and that after considering the work it has to do, it is found that a magnetising power of 2,400 turns is required; suppose, also, that it is laid down as a condition that the coil must not warm up more than 50deg. F. above the surrounding air—what volume of coil will be required. Assume first that the current will be one ampere; then there will have to be 2,400 turns of a wire which will carry one ampere. If we took a No. 20 S.W.G. wire and wound it to a depth of ½in., that would give 220 turns per inch length of coil; so that a coil 11in. long and a little over ½in. deep (or 10 layers deep) would give 2,400 turns. Now Table X. shows that if this wire were to carry 1·018 ampere, it would heat up 225deg. F. if wound to a depth of 3·9in. If wound to ½in., it would therefore heat up about 30deg. F., and with only one ampere would, of course, heat less. This is too good; try the next thinner wire. No. 22 S.W.G. wire at 2,000 amperes to square inch will carry 1·23 amperes, and heats 225deg. if wound up to 1·13in. If it is only to heat 50deg. it must not be wound more than ¼in. deep; but if it only carries current of one ampere it may be wound a little deeper, say, to 14 layers. There will then be wanted a coil about 7in. long to hold the 2,400 turns. The wire will occupy about 3·85 square inches of total cross-section; and the volume of the space occupied by the winding will be 26·95 cubic inches. Two bobbins, each 3½in. long and ·65 deep, to allow for 14 layers, will be suitable to receive the coils.

By the light of the knowledge one possesses as to the relation between emissivity of surface, rate of heating by current, and limiting temperatures, it is seen how little justification there is for such empirical rules as that which is often given—namely, to make the depth of coil equal to the diameter of the iron core. Consider this in relation to the following fact: that in all those cases where leakage is negligible, the number of ampere-turns that will magnetise up a thin core to any prescribed degree of magnetisation will magnetise up a core of any section whatever, and of the same length, to the same degree of magnetisation. A rule that would increase the depth of copper proportionately to the diameter of the iron core is absurd.

Where less accurate approximations are all that is needed, more simple rules can be given. Here are two cases:

Case 1. *Leakage assumed to be negligible.*—Assume B = 16,000, then H = 50 (see Table III). Hence the ampere-turns per centimetre of iron will have to be 40, or per inch of iron, 120; for H is equal to 1·2566 times the ampere-turns per centimetre. Now if the winding is not going to exceed ½in. in depth, we may allow 4,000 amperes per square inch without serious overheating. And the 4,000 ampere-turns will require 2in. length of coil, or each inch of coil carries 2,000 ampere-turns without overheating. Hence each inch of coil ½in. deep will suffice to magnetise up 20in. length of iron to the prescribed degree.

Case 2. *Leakage assumed to be 50 per cent.*—Assume B in air gap = H = 8,000, then to force this across requires ampere-turns 6,400 per centimetre of air, or 16,250 per inch of air. Now if winding is not going to exceed ½in depth. each inch length of coil will carry 2,000 ampere-turns. Hence 8in. length of coil ½in. deep will be required for 1in. length of air, magnetised up to the prescribed degree.

WINDINGS FOR CONSTANT PRESSURE AND FOR CONSTANT CURRENT.

In winding coils for magnets that are to be used on any electric light system, it should be carefully borne in mind that there are separate rules to be considered according to the nature of the supply. If the electric supply is at constant pressure, as usual for glow lamps, the winding of coils of electromagnets follows the same rule as the coils of voltmeters. If the supply is with constant current, as usual for arc lighting in series, then the coils must be wound with due regard to the current which the wire will carry, when lying in layers of suitable thickness, the number of turns being in this case the same whether thin or thick wire is used.

If we assume that a safe limit of temperature is 90deg. F. higher than the surrounding air, then the largest current which may be used with a given electromagnet is expressed by the formula:

$$\text{Highest permissible amperes} \quad 0{\cdot}63 \sqrt{\frac{s}{r}}$$

where s is the number of square inches of surface of the coils, and r their resistance in ohms.

Similarly for coils to be used as shunts we have:

$$\text{Highest permissible volts} = 0{\cdot}63 \sqrt{s\,r}$$

The magnetising power of a coil, supplied at a given number of volts of pressure, is independent of its length, and depends only on its gauge, but the longer the wire the less will be the heat waste. On the contrary, when the condition of supply is with a constant number of amperes of current, the magnetising power of a coil is independent of the gauge of the wire, and depends only on its length, but the larger the gauge the less will be the heat waste.

MISCELLANEOUS RULES ABOUT WINDING.

To reach the same limiting temperature with bobbins of equal size wound with wires of different gauge, the cross-section of the wire must vary with the current it is to carry; or, in other words, the current density (amperes per square inch) must be the same in each. Table X. shows the amperages of the various sizes of wires at four different values of current density.

* The *watt* is the unit of rate of expenditure of energy, and is equal to 10,000,000 ergs per second, or to $\frac{1}{746}$th of a horse-power. A current of one ampere, flowing through a resistance of one ohm, spends energy in heating at the rate of one watt. One watt is equivalent to 4·2 calories per second of heat—that is to say, the heat developed in one second, by expenditure of energy at the rate of one watt, would suffice to warm one gramme of water through 4·2deg. C. As 252 calories are equal to one British (lb. F.) unit of heat, it follows that heat emitted at the rate of one watt would suffice to warm 17¼lb. of water 1deg. F. in one minute; or, one British unit of heat equals 1,058 watt-seconds.

TABLE X.—WIRE GAUGE AND AMPERAGE TABLE.

Dimensions.					Permissible Amperage, Probable Heating, and Permissible Depth.											
S.W.G.	Diam. (inch).	Section (sq. inch bare).	Turns to 1 linear inch (covered).	Turns per sq. inch (covered).	At 1,000 amps. to sq. inch.			At 2,000 amps. to sq. inch.			At 3,000 amps. to sq. inch.			At 4,000 amps. to sq. inch.		
					A	F	D	A	F	D	A	F	D	A	F	D
22	·028	·00062	23·81	624·	·616	2·28	4·5	1·23	9·12	1·13	1·85	20·52	·50	2·46	36·5	·28
20	·036	·0010	20·00	440·	1·018	3·18	3·9	2·036	12·72	·97	3·05	28·62	·43	4·07	50·9	·24
19	·040	·0012	18·52	377·	1·26	3·56	3·6	2·52	14·24	·92	3·78	32·04	41	5·04	57·0	·23
18	·048	·0018	16·13	286·	1·81	4·64	3·3	3·62	18·56	·83	5·43	41·76	·37	7·24	74·2	·21
17	·056	·0024	14·28	224·	2·4	5·47	3·2	4·8	21·9	·79	7·2	49·2	·35	9·6	87·5	·19
16	.064	·0032	12·83	181·	3·2	6·57	3·0	6·4	26·3	·74	9·6	59·1	·33	12·8	105·1	·18
15	·072	·0040	11·63	149·	4·0	7·40	2·9	8·0	29·6	·72	12·0	66·6	·32	16·0	118·4	·17
14	·080	·0050	10·64	124·	5·0	8·46	2·8	10·0	33·8	·70	15·0	76·3	·31	20·0	135·4	·17
13	·092	·0060	9·44	98·2	6·6	9·97	2·7	13·2	39·9	·67	19·8	89·7	·30	26·4	159·5	·16
12	·104	·0085	8·48	79·1	8·5	11·53	2·6	17·0	46·1	·65	25·5	103·8	·29	34·0	184·4	·16
11	·116	·0105	7·69	65·0	10·5	12·8	2·5	21·0	51·2	·63	31·5	115·2	·28	42·0	204·8	·16
10	·128	·0128	7·04	54·5	12·8	14·3	2·4	25·6	57·2	·61	38·4	128·7	·27	51·2	228·8	·15
9	·144	·0163	6·33	44·1	16·3	16·4	2·4	32·6	65·6	·60	48·9	147·6	·27	65·2	262·4	·15
8	·160	·0201	5·74	36·3	20·1	18·4	2·3	40·2	73·6	·59	60·3	165·6	·26	80·4	294·4	·15
7	·176	·0243	5·26	30·4	24·3	20·4	2·3	48·6	81·6	·58	72·9	183·6	·26	97 2	326·4	·15
Strand'd																
7/22	0·84	·0043	9·62	101·8	4·3	6·73	4·0	8·6	26·9	·99	12·9	24·6	·44	17·2	107·7	25
7/20	·108	·0072	7·81	67·1	7·13	8·94	3·7	14·3	35·7	·92	21·4	80·5	·48	28·5	143·0	·23
7/18	·144	·0128	6·09	40·8	12·7	12·4	3·4	25·4	49·6	·83	38·1	111·6	·39	50·8	198·4	·21
7/16	·192	·0229	5·10	28·6	22·9	17·2	3·2	45·8	68·7	·79	68·7	154·5	·35	91·6	274·7	·20
7/15	·216	·0289	4·27	20·1	28·9	19·5	3·1	57·8	78·0	·78	86·7	175·4	·34	115·6	311·8	·20
7/14	·240	·0356	3·87	16·5	35·6	21·8	3·1	71·2	87·1	·76	106·8	195·9	·34	142·4	348·3	·19
7/13	·276	·0462	3·38	12·6	46·2	24·7	3·0	92·4	98·8	·74	138·6	222·3	·33	184·8	395·2	·19
7/12	·312	·0595	3·01	9·97	59·5	28·5	2·9	179·0	114·0	·72	178·5	256·5	·32	238·0	456	·18

Figures in columns marked A signify number of amperes the wire carries.

Figures in columns marked F signify number of degrees (Fahrenheit) that the coil will warm up if there is only one layer of wire, and on the assumption that the heat is radiated only from the outer surface of the coil; they are calculated by the following modification of Forbes's rule:

Rise in temperature (Fahrenheit degrees) = 225 × No. of watts lost per square inch.
= 159 × sectional area × number of turns to 1in. (at 1,000 amperes per square inch).

Figures in columns marked D are the depths in inches to which wire may be wound if one watt be lost by each square inch of radiating surface, the outside radiating surface of the bobbin being only considered.

Rule for calculating a 7-strand cable: Diameter of cable = 1·134 × diameter of equivalent round wire.

Figures under heading "Turns to 1 linear inch," are calculated for cotton-covered wires of average thicknesses of coverings used for the different gauges—viz., 14 mils additional diameter on round wires (from No. 22), and 20 mils on stranded or square wire.

Figures under heading "Turns per square inch," are calculated from preceding, allowing 10 per cent. for bedding of layers.

Resistance (ohms) of coil of copper wire, occupying v cubic inches of coil space, and of which the gauge is d mils uncovered, and D mils covered, may be approximately calculated by the rule:

$$\text{Ohms} = 960{,}700 \, \frac{v}{D^2 \, d^2}.$$

The data respecting sizes of wires of various gauges are kindly furnished by the London Electric Wire Company.

To raise to the same temperature two similarly shaped coils, differing in size only, and having the gauges of the wires in the same ratio (so that there are the same number of turns on the large coil as on the small one), the currents must be proportional to the square roots of the cubes of the linear dimensions.

Sir William Thomson has given a useful rule for calculating windings of electromagnets of the same types but of different sizes. Similar iron cores, similarly wound with lengths of wire proportional to the squares of their linear dimensions, will, when excited with equal currents, produce equal intensities of magnetic field at points similarly situated with respect to them.

Similar electromagnets of different sizes must have ampere-turns proportional to their linear dimensions if they are to be magnetised up to an equal degree of saturation.

It is curious what erroneous notions crop up from time to time about winding electromagnets. In 1869 a certain Mr. Lyttle took out a patent for winding the coils in the following way: Wind the first layer as usual, then bring the wire back to the end where the winding began and wind a second layer, and so on. In this way all the windings will be right-handed, or else all left-handed, not alternately right and left as in the ordinary winding. Lyttle declared that this method of winding a coil gave more powerful effects; so did M. Brisson, who reinvented the same mode of winding in 1873, and solemnly described it. Its alleged superiority was at once disproved by Mr. W. H. Preece, who found the only difference to be that there was more difficulty in carrying out this mode of winding.

Another popular error is that electromagnets in which the wires are badly insulated are more powerful than those in which they are well insulated. This arose from the ignorant use of electromagnets having long thin coils (of high resistance) with batteries consisting of a few cells (of low E.M.F.). In such cases, if some of the coils are short-circuited, more current flows, and the magnetising power may be greater. But the scientific cure is either to rewind the magnet with an appropriate coil of thick wire, or else to apply another battery having an E.M.F. that is greater.

(To be continued.)

Physical Society.—In the report of the meeting of this society given in our last issue, on page 463, in col. 2, line 58, after *square* insert *roots*.

LEGAL INTELLIGENCE.

DICKINS AND JONES v. METROPOLITAN ELECTRIC SUPPLY COMPANY.

This action came before Mr. Justice Stephen in the Queen's Bench Division of the High Court of Justice on Wednesday.

Messrs. Dickins and Jones, of Regent-street, sued the company to recover damages for an alleged breach of a contract to supply the electric light to their place of business. The defendants denied that there was any written agreement with the plaintiffs as alleged, such an agreement was an agreement at will only, and made subject to a proviso that the defendants were not to be liable to any damage by accidental interruptions, and that the said supply was interrupted, if at all, accidentally, by reason of the overhead wires being in an unsafe condition in November, 1889, and the defendants could not, by reason of the Electric Lighting Orders Confirmation Act of 1889, enter upon the area or district in which the plaintiffs' premises were for the purposes of replacing the said wires. For the same same reason on November 16, 1889, the date of the matters complained of, the defendants contended they were prohibited from supplying the plaintiffs any longer under their contract, and only continued to supply them upon sufferance, and so long as they were permitted to do so by the Board of Trade, and then when, under the new regulations of that authority, consequent upon the new Electric Lighting Act, the defendants' supply cable became insufficient as not conforming to the new requirements, they had been compelled to cut off the supply of the electric current. The defendant company further stated that when this had been done they had, on November 25, written the plaintiffs offering to provide and fix suitable plant at the plaintiffs' cost, and to continue the supply, but that the plaintiffs refused their offer. In reply to the defendants' statutory defence, the plaintiffs pleaded that on May 20, 1889, the defendants were supplying the electrical energy to their premises, and that, therefore, under section 6 of the Act they were permitted to continue such supply until September 29, 1890.

Mr. Jelf, Q.C., and Mr. M'Call appeared for the plaintiffs; and Mr. Lumley Smith, Q.C., and Mr. R. S. Wright were for the defendant company.

Evidence was given that prior to 1888 the plaintiffs' premises had been supplied with the electric light by the Grosvenor Company, and subsequently by Messrs. Pritchett and Co., of

Owing to their being in unity with the Edison-Swan Company, they were able to play into one another's hands, and it happened that a demand set in for a particular kind of lamp in Germany, which the Edison Company could not supply and they could, and the £9,115. 16s. 8d. represented the lamps made and material used.

The next items were office expenses, Directors' fees, rent, salaries, income tax, etc., £3,513; wages and expenses at factory, £5,046—that was, wages and expenses as distinct from material or lamps; depreciation, the item already referred to, £490; sales, ledger reserve, £150. This was in case they made bad debts. They had no anticipation of doing so, only they liked to be on the right side. On the other side of the account there was the item "By sales, less commission and allowances, £12,347; transfer fees and interest, £1,768." Now, these two items were realised from what might be called the open asset of the Swan Company—the power to make lamps in Germany, or to license it to somebody else; and the interest on investments—£5,120 in Prussian Consols, and £29,000, in round numbers, in English Consols. Then they came to the income depending upon the fixed investments—namely, the dividend on shares in La Compagnie Générale £1,771, and dividends on shares in the Edison and Swan United Electric Light Company £30,665, which was a big figure. In fact, this sum came to 8 per cent. upon the whole capital. That was a very important thing, and those gentlemen who had taken sufficient interest in the affairs of the Edison and Swan Company to attend their meetings or read their reports would know, humanly speaking, that the future of that company was likely to be fairly prosperous. They had protection for a certain number of years, but their policy had not been founded upon protection at all, but upon their having at the end of the protected time such a character, *clientèle*, and capacity for production that nobody else could compete against them. They must work to that standard. As long as the protecting period lasted there was no doubt that the dividend of the Edison-Swan Company might be looked for as being a very tolerable one. The French Company, which had only started very recently, had a fine factory, but had not yet done as much as they had in the production of lamps. They did not make nearly as many. But it took a certain time to develop an efficient lamp, combined with an economical one. The processes were so multifarious and technical that it wanted considerable practice to get into the best groove. There was the advantage of having the Edison-Swan interested in it as partners. They were able to give them the aid their experience as gained at Ponders End, where they had the advantage of having the technical knowledge of Mr. Swan, and had succeeded in producing efficient lamps at a moderate price. The French Company had had the benefit of their knowledge, and they hoped they would pay 6 per cent. on the investment. Their (the French Company's) year ended later, and they ought to have some dividend from them, but they had thought it prudent to wait for it. Litigation was still going on in France about patents, because although they had wisely put their horses together, there were in France, as in other places, a great number of people who liked to avail themselves of the fruit of other people's brains without payment. So there were a number of infringers, and the same process was going on there as had been here, and the French Company were standing on their patents. They blamed the lawyers in England, but their experience in Germany was only capped by their experience of France in getting legal matters settled, and until they were settled they did not know the value of their business. As regarded the German patent suit the Court of Appeal gave it in their favour, though they had lost it in the first Court, the judge giving judgment against them in spite of a report in their favour from the Patent Department. Of course, if they were held to have infringed the Edison patent, it would be a serious matter, and they would have to shut up shop. They were making lamps in Germany, and making them at a small profit. Until the decision of the Supreme Court of Leipsic had been heard, they would not know which way it would go. The Compagnie Général were contesting (upholding) the validity of the French patents, and hoped to get a decision next spring, meanwhile they were going on making lamps and selling them. Pending the determination of these judicial proceedings everybody made lamps and sold them, and that affected the price, which had to be even with that of the infringer. Of course, what might happen there was what happened in this country, when they got hold of two or three infringers, these had to reimburse them in good solid sums. That might take place both in Germany and France. He would invite questions, and conclude by moving the adoption of the report and accounts subject thereto.

Mr. F. R. Leyland (deputy chairman) seconded the motion.

Mr. Mills asked, as to the sum of money in consols (£29,004), what was the object of keeping such a large sum there; also as to the £208,478, which paid them 15 per cent., whether this 15 per cent. was fairly earned this year, or whether it was in payment of arrears previously owing; as to the increase in the stock by about £8,000, he should have thought it would have been decreased rather than increased; as to the office expenses, which seemed to him large where the sales were only £12,000, and the duties of the Directors consisted, as far as he could judge, in receiving the dividends from the Edison and French Company?

In reply, the **Chairman** explained as to the Edison dividend that there were certain deferred shareholders in the Edison Company (the Swan Company being the largest among them) who were entitled out of the profits of each year to an accumulated dividend of 7 per cent. As to the stock of lamps, they had already sold about half for nearly as much money as the whole stock was valued at in the balance-sheet. They thought it prudent to put the stock in the accounts at cost price, and they were justified by what had just said in so doing. As to office expenses, the Directors got £1,500 for their year's services, and that was cheap. They were not mere machines for taking over and distributing the money earned in other concerns. They were conducting the most serious litigation affecting the Company's interest in other countries. The fortune of the two Companies had been made by the energy, and zeal, and infinite pugnacity which had resulted in success, and they must pay for it. What was £1,500 a year? Why, their lawyers took it out in half a term. Germany was a long way off, and to conduct a small business in Germany was much more difficult than to do so in London. He hoped they should hear no more about this. As to the investment in consols, they had more money than they wanted. It was easy to talk of paying it back to the shareholders, but that meant reducing the capital and going to the Court of Chancery. Besides, if the litigation he had mentioned went in their favour, their business would increase, and they would want a great deal of money to extend it in Germany, where they were working with a very small capital at present. They did not want to put money into workshops there yet; in fact, they only rented a factory and made temporary arrangements, keeping their money in their pockets pending the result of the litigation.

A **Shareholder** asked when the patent expired, and the **Chairman** said at the end of between three and four years, with no chance of prolonging it. If, however, they had not got a character at the end of that time they would not deserve to have it. There was evidence of an enormous increase in electric lighting. They gave up installing, and left the risk of that business to other people with more money and enthusiasm, and these were installing now in all directions, London being, if anything, more behind in this respect than other places. Who knew how many lamps would be required in four years' time? If they only got a tithe of the business then they ought to make a handsome profit.

The **Chairman** moved: "That in addition to the interim dividend at the rate of 6 per cent. per annum for the six months ended March 31, 1890, already distributed, a dividend at the rate of 6 per cent. per annum be, and is hereby, declared on the shares of the Company for the half-year ended September 30, 1890 (making 6 per cent. for the year), and of 4 per cent. for the 12 months ended September 30, 1890, free of income tax, to be distributed in accordance with the provisions of clause 79 of the articles of association." He observed that the dividend works out to the following amount per share: On the 78,949 ordinary shares, 4s. 10½d. per share; on the 19,750 fully-paid shares, 5s. 7½d. per share.

This was seconded by **Mr. Leyland** and carried.

Resolutions re-electing Messrs. F. R. Leyland and W. C. Quilter, M.P., as directors, and Messrs. Welton, Jones, and Co., auditors.

The meeting closed with the usual vote of thanks to the Chairman, which was seconded by **Mr. Mills**, who disclaimed any intention of questioning the remuneration of the Directors.

The **Chairman**, in the course of his reply, remarked that when the litigation was brought to a close in Germany the necessity for keeping the Edison-Swan and the Swan United Company's as two separate undertakings would cease, and he supposed it would be a prudent thing and wise upon some terms or other to put both those hats under one umbrella, and that would materially reduce the considerable charge of £3,500 a year for working a separate concern. That could not be done, however, until they knew what their legal position in Germany was.

MONTEVIDEAN AND BRAZILIAN TELEGRAPH COMPANY.

On Tuesday morning, at an extraordinary general meeting of the Montevidean and Brazilian Telegraph Company, held at the offices, Langthorn House, Copthall-avenue, Dr. Cameron, M.P., in the chair, a series of formal resolutions were submitted by which it is proposed to voluntarily wind up the Company, to appoint Mr. George Fraser as the liquidator, and to enter into an agreement for the sale and transfer to the Western and Brazilian Telegraph Company, Limited, of the whole of the Montevidean and Brazilian Telegraph Company's undertaking.

The resolutions having been adopted, the proceedings closed

COMPANIES' REPORTS.

ELECTRIC CONSTRUCTION CORPORATION, LIMITED.

Directors: Sir Henry C. Mance, C.I.E., chairman, J. Spencer Balfour, Esq., M.P. (vice-chairman), Sir Daniel Cooper, Bart., G.C.M.G., Sir R. N. Fowler, Bart., M.P., John Irving Courtenay, Esq., George Dibley, Esq., Henry P. Holt, Esq., Joseph Moseley, Esq., James Pender, Esq., J. B. Verity, Esq., H. Granville Wright, Esq., Joseph Ebb-Smith, Esq. (managing director), Thomas Parker, Esq. (works director). Secretary: F. Walto , Esq.

Report of the Directors to be submitted to the shareholders at the ordinary general meeting to be held at Worcester House, Walbrook, London, E.C., on Monday, 8th December, 1890, at 12 o'clock noon.

The Directors beg to submit the accounts of the Corporation up to September 30th, 1890, showing a profit of £52,639. 3s. 2d. This may be considered as eminently satisfactory, having regard to the facts that (1) the Corporation did not enter into full possession of all the properties acquired until October 31st, 1889; and (2) the Corporation has not during the past year had the benefit of the

increased power and economy of production to be derived from the new Bushbury Works, to which special reference is hereafter made. From the profit of £52,639. 3s. 2d., the Board have written off the whole of the preliminary expenses of the formation of the Corporation, amounting to £4,348. 7s. 6d., and they have also carried to capital account a considerable sum resulting from licenses and re-sales of patents. No patents have been sold or licenses granted which can, in the opinion of the Directors, prejudice the profit-earning power of the Corporation, and possibly a certain portion of the amount so applied to capital might have been regarded as divisible profits; but, having regard to the large amount of the capital of the Corporation at present represented by the patent rights, the Directors are satisfied that the shareholders will support the more prudent policy which has been adopted. From the profit balance of £48,290. 15s. 8d. the Directors recommend (1) that the sum of £15,000 be placed to reserve account against depreciation; (2) that a dividend of 6 per cent. be declared and paid upon the capital which has been from time to time called up, and paid in respect of the ordinary shares of the Corporation, from the date of allotment on the 7th day of June, 1889, to the 30th day of September, 1890, inclusive, carrying forward the balance to the current year's account. At an early date after acquisition of the Elwell-Parker business, the Directors satisfied themselves that the existing Wolverhampton (Commercial-road) works were inadequate to cope with the large and increasing orders for electrical goods, and particularly for those of the heavier class now in demand for central stations. A very advantageous site was secured at Bushbury, near Wolverhampton, immediately adjoining and in direct communication with the London and North-Western Railway Company. Works have been there erected which, it is believed, will enable the Corporation to supply electrical work of any class; but, having regard to the manner in which the business of the Corporation has developed, provision has been made for still further extensions should the necessity arise. The cost of the construction of these works, with the necessary land, sidings, and machinery, has, of necessity, been great; but the Directors are satisfied that the capital of the Corporation has been well expended. In the prospectus of the Corporation it was stated that "As the business and profits of the Corporation increase the Directors will from time to time propose the issue of additional capital, but care will be taken that the holders of the original capital shall be entitled to a preference or priority of allotment in subsequent issues." To secure the full advantage and profits of increasing business, it is desirable that a considerable addition should be made to the resources of the Corporation. In the opinion of the Directors a debenture issue would be more economical and advantageous to the present shareholders than an increase of capital either by ordinary or preference shares. Subject to any expression of opinion on the part of the shareholders at the general meeting, the Directors therefore propose to make a sufficient debenture issue. Care will be taken that shareholders desiring to subscribe to these debentures shall have the opportunity of doing so. In accordance with the articles of association, four of the Directors—viz., Sir Daniel Cooper, with Messrs. Balfour, Courtenay, and Dibley—retire from the Board, all of whom are eligible, and offer themselves for re-election. The Directors regret that the pressure of his professional engagements has compelled Sir Douglas Fox to resign his seat at the Board. Sir Henry C. Mance, C.I.E., has consented to give the Corporation the benefit of his great experience and scientific knowledge, as chairman of the Board. Messrs. Broads, Paterson, and Co., the present auditors of the Corporation, retire and offer themselves for re election.

PROFIT AND LOSS ACCOUNT, FROM 7TH JUNE, 1889, TO 30TH SEPTEMBER, 1890.

DR.	£ s. d.	£ s. d.
To expenses and cost of production during the year ended 30th September, 1890, at Wolverhampton and Millwall, including engineering department and provision for bad debts		173,266 0 9
To head office expenses, including rents, patent expenses, Directors' fees, Managing Director's salary, accountancy, etc.		14,468 10 4
To Auditors' fees		105 0 0
To interest upon temporary loans, etc.		4,837 18 7
To other expenses, including the estimated cost of goods, etc., sent to Edinburgh Exhibition, and advertising		3,948 7 6
To balance carried to balance-sheet		52,639 3 2
		£249,265 0 4
CR.		£ s. d.
By apportionment of profit between the vendor and the Corporation: Proportion accruing to the Corporation from 7th June to 30th September, 1889		4,061 11 7
By sales and work executed during the year ended 30th September, 1890		222,734 13 1
By cash and shares for licenses granted, patents resold, and profits upon formation of subsidiary companies	£121,963 12 5	
Less estimated amount applicable to capital account	100,000 0 0	
		21,963 12 5
By transfer fees, rents received, and miscellaneous receipts		505 3 3
		£249,265 0 4

BALANCE-SHEET, SEPTEMBER 30TH, 1890.

DR.		£ s. d.	£ s. d.
To capital—			
49,900 ordinary shares of £10 each		£499,000 0 0	
100 founders' shares of £10 each		1,000 0 0	
		500,000 0 0	
Less calls in arrear		16,074 0 0	
			483,926 0 0
To liabilities—			
Trade accounts, Wolverhampton and Millwall		33,068 8 11	
Capital accounts		17,555 17 10	
Loan secured by debentures		40,000 0 0	
Directors		792 3 9	
			91,416 10 6
By contingent liabilities— On pending contracts and in shares partly paid up, and bills receivable discounted		£113,364 0 0	
By profit and loss account—			
Balance as per statement from June 7th, 1889, to September 30th, 1890		52,639 3 2	
Deduct preliminary expenses written off		4,348 7 6	
			48,290 15 8
			£623,633 6 2
CR.			£ s. d
By purchase of the works, businesses, and patents of Elwell-Parker, Limited, of Wolverhampton, and of the Electrical Power Storage Company, Limited, of London, patent rights, etc., according to prospectus		£397,300 0 0	
Less stock, book debts, etc.	£85,303 2 4		
Licenses granted and patents sold, see profit and loss account	100,000 0 0		
		185,303 2 4	
			211,996 17 8
By expenditure since—			
Liabilities of the Wolverhampton business at the date of purchase, etc.			40,189 1 3
Land and buildings at Bushbury, new works, Wolverhampton			46,395 11 8
Plant and machinery, etc.			12,763 17 11
Furniture, fixtures, etc.			1,471 7 11
			312,816 16 5
By shares in subsidiary companies at par, shares included in the original purchase at nominal value, and debts due by subsidiary companies			128,117 0 0
By book debts—			
Wolverhampton and Millwall accounts		£71,805 6 1	
Head office accounts		20,985 4 9	
The vendor, for liabilities of the businesses purchased, paid by the Corporation		12,091 14 7	
			104,882 5 5
By stocks at Wolverhampton and Millwall			34,640 7 4
By cash at bankers			36,984 9 3
By bills in hand			6,192 7 9
			£623,633 6 2

PROVISIONAL PATENTS, 1890.

NOVEMBER 17.

18491. **Improvements in dynamo-electric machines.** Rankin Kennedy, 10, India-street, Kilmarnock. (Complete specification.)

18537. **Improved method of signalling on railways, and appliances connected for electrically operating same.** Edward Samuel Cook, 166, Fleet-street, London.

18554. **Improvements relating to the fixing in insulating bases of blocks for connecting electrical conductors.** Henry James Pierce, 18, Buckingham-street, Strand, London.

18555. **Improvements in electrical switches.** Henry James Pierce, 18, Buckingham-street, Strand, London.

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18558. **Improvements relating to electrical pendants and other portable or movable electrical devices.** Henry James Pierce, 18, Buckingham-street, Strand, London.

NOVEMBER 18.

18576. **Improvements in apparatus for controlling electric currents.** Ralph Henry Christopher Nevile, 2, Great George-street, Westminster. (Complete specification.)

18587. **Improved form of electric locomotive.** John Platt, High Orchard-road, Gloucester. (Francis W. Dean, United States.)

18589. **Improvements in electric railway signals.** William Henry Waddell, 46, Lincoln's-inn-fields, London. (Complete specification.)

18625. **Improvements in and relating to apparatus for use in electric welding, forging, and other metal-working operations.** Henry Harris Lake, 45, Southampton-buildings, London. (Hermann Lemp, United States.) (Complete specification.)

18631. **Improvements relating to the welding of metals by electricity.** Henry Harris Lake, 45, Southampton-buildings, London. (Elihu Thomson, United States.) (Complete specification.)

18638. **Improvements in electricity meters.** Eugen Hartmann and Wunibald Braun, 47, Lincoln's-inn-fields, London. (Complete specification.)

18660. **An improved terminal for electric lampholders.** Andrew Jackson McGeoch, Temple-chambers, London.

18661. **Improvements in the construction of plates for secondary batteries.** Job Thomas Niblett, 6, Bream's-buildings, London.

18663. **An improved instrument for removing the covering from insulated wires.** Oscar May, 45, Southampton-buildings, London.

NOVEMBER 19.

18695. **Improvements in armatures for dynamo-electric machines.** John Henry Holmes, Portland-road, Newcastle-on-Tyne.

18699. **Improvements in electric circuit closers or push buttons.** William S. Thomson and Hjalmar von Kohler, 55, Chancery-lane, London. (Complete specification).

NOVEMBER 20.

8776. **Electric telegraphic communication between termini, intermediate stations, etc., and railway trams or vehicles in motion.** Arthur Thomas James Cutmore and Francis Hermin Bointon, 41, Furnival-street, Holborn Bars, London.

18791. **Improvements in fixings for exposed telegraph wires to insulators.** Oliver Imray, 28, Southampton-buildings, London. (Joao Nepomucono Baptista, Brazil.)

18796. **An improved locking sash fastener and electrical alarm and indicator for windows, doors, and like purposes.** John Benford, 97, Newgate-street, London.

NOVEMBER 21.

18836. **Improvements in meters for measuring electricity.** William Friese-Greene, 92, Piccadilly, London.

18890. **Improvements in automatic telephone connectors.** James Yate Johnson, 47, Lincoln's-inn-fields, London. (The Automatic Electric Exchange Company, United States.) (Complete specification.)

18896. **Improvements in the process and apparatus for manufacturing copper tubes, sheets, strips, and wires by electrolysis.** Alexander Stanley Elmore, 28, Southampton-buildings, London. (Complete specification.)

18904. **Improvements in magneto-electric telephonic apparatus.** Harry Thomas Ogilvie Fraser, 47, Lincoln's-inn-fields, London.

18910. **Improved apparatus for stopping machinery by electricity.** Cesar Felix Josz, 4, South-street, Finsbury, London.

18913. **An improved electrical switch.** Edward Lionel Joseph, 115, Cannon-street, London.

18916. **Improvements in or appertaining to apparatus for measuring electric currents.** Hermann Aron, 6, Lord-street, Liverpool.

18926. **Improvements in electric arc lamps.** François Suisse, 54, Fleet-street, London.

NOVEMBER 22.

18969. **An improved apparatus for measuring the resistance and insulation of electric conductors.** William Arthur Price and William Ernest Gray, 6, Bream's-buildings, London.

18993. **Improvements in and relating to electric clocks.** Nicolaus Prokhoroff and Nicolaus Fahlberg, 45, Southampton-buildings, London. (Complete specification.)

SPECIFICATIONS PUBLISHED.

1889.

17424. **Electric conductors.** Andrews. 6d.

20311. **Lightning arresters.** Thompson (Westinghouse Electric Company). 8d.

20393. **Lighting trains by electricity.** Jenkin. 8d.

20764. **Electric generators.** Thompson (The Westinghouse Electric Company). 8d.

20885. **Electric, etc., lamps.** Price. 6d.

1890.

12080. **Electrical switches.** Baker. 8d.

8393. **Electrical switches.** Drake and others. 8d.

11440. **Electric railways.** Mansfield. 1s. 3d.

14817. **Distribution of electrical energy.** Kennedy. 8d.

15456. **Welding metals electrically.** Thompson (Coffin). 6d.

15482. **Electric batteries.** Lake (Crosby Electric Company). 6d.

NEW COMPANIES REGISTERED.

Blackpool South Shore Pier and Pavilion Company, Limited. Registered by Field, Roscoe, and Co., 36, Lincoln's-inn-fields, with a capital of £60,000 in £1 shares. Object: to erect at South Shore, Blackpool, a promenade pier and landing stage, with pavilion, concert-room, swimming and other baths, etc. The first directors are G. Hardy, Pickering Lodge, Timperley; H. Buckley, Blackpool; James Cardwell, Martin, near Blackpool; James Crabtree, South Shore; C. Estcourt, Old Trafford; and Robert Lee, Manchester.

Chagford and Devon Electric Light Company, Limited.—Registered by James Fleming, 27, Martin's-lane, Cannon-street, with a capital of £2,000 in £1 shares. Object: to carry on the business of electrical engineers. Registered without articles.

"Electricity and Electrical Engineering" Newspaper Company, Limited.—Registered by Bowman and Crawley Boevey, 21, Bedford-row, W.C., with a capital of £500 in £10 shares. Object: to establish a newspaper in the interest of electrical science. Registered without articles of association.

Electrolytic Syndicate, Limited.—Registered by the Metropolitan and Provincial Syndicate, Limited, Lonsdale-chambers, 27, Chancery-lane, with a capital of £100,000 in £1 shares. Object: to carry into effect the following agreements: (1) an agreement made October 25 between William Elmore and Alfred Wells; (2) an agreement made October 24 between Arthur Cooper and Alfred Wells; (3) an agreement made October 25 between John Fraser and Alfred Wells; (4) an agreement made October 23 between Woodhouse and Rawson United, Limited, of the first part, William Elmore, Frank Elmore, and A. S. Elmore of the second part, and Alfred Wells of the third part; to carry on as principals or agents business as miners, metallurgists, and smelters. The first subscribers are:

	Shares.
J. J. Atkinson, Cosgrove Priory, Northants	1
W. Elmore, 47, Clapham-road, S.W.	1
J. T. Cooper, Cregg, Nightingale-lane, S.W.	1
F. Safford, 2, Garden-court, Temple	1
S. Evans, Lonsdale-chambers, Chancery-lane	1
W. J. Tipputt, 11, Maiden-lane, E.C.	1
W. J. Peck, Redcar House, Redcar	1

Registered without articles of association.

Ernest Scott and Mountain, Limited.—Registered by Slaughter and May, 21, Great Winchester-street, E.C., with a capital of £70,000 in £10 shares. Object: to carry into effect (1) an agreement, made October 11, between Ernest Scott, trading as Ernest Scott and Co., and E. H. Turner; (2) an agreement of the same date, made between E. H. Turner and Ernest Scott; (3) an agreement of the same date, made between E. H. Turner and William C. Mountain; to carry on the business of electrical and general engineers, machine, and engineering tool makers, etc. The first subscribers are:

	Shares.
P. W. Bullock, 19, Portsea-place, Connaught-square	1
J. Aspinall, 34, Bowman's-buildings, Edgware-road	1
J. McNab, Draper's-gardens, E.C.	1
W. A. Slaughter, 21, Great Winchester-street, E.C.	1
D. Scott, 12, York-street, Manchester	1
A. Barttell, 21, Great Winchester-street	1
S. E. Preston, 21, Great Winchester-street	1

There shall not be less than three nor more than five Directors. The first to be appointed by the subscribers to the memorandum of association. Qualification, £1,000. Remuneration, £200 each.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the past week amounted to £5,637.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting the "fifth" payable to the London Platino-Brazilian Company, were £4,421.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2½
Swan United	3¾	5¼
Crompton & Co., Pref.	—	5¼
National Telephone	5	5¼
Electric Construction	10	8

NOTES.

The Khojak Tunnel Works are lighted by incandescents of 8 c.p.

Carlsbad is to have an electric railway running between the railway station and the town.

Wrexham.—It is stated that the electric light is to be introduced at the post office and St. James's Hall.

Folkestone.—The Lighting Committee have been instructed to present a report as to the electric lighting contract.

City Lighting.—The work by the Brush Electric Company upon the City lighting is to be commenced within the next month.

Gibraltar and Malta.—Mr. W. H. Preece has been commissioned to report as to the adoption of electric lighting here.

The Burslem Town Council have resolved to oppose the Electric Installation and Maintenance Company's application for an order.

Mining Plant for Sweden.—An electric mining plant has been dispatched this week by the General Electric Traction Company to Sweden.

Electric Traction.—The Halle (Saxony) Tramway Company has adopted electric traction on the system worked by the Allgemeine Elektricitäts Gesellschaft.

City and Guilds Institute.—The Court of Common Council has granted £500 to the institute for the present year, but not without considerable discussion.

Halifax (Nova Scotia).—The War Department are considering the question of fitting up electric lights in the York Redoubt, at the entrance to the harbour.

Electro-Harmonic Society.—We would remind our readers that next Monday is the ladies' night at St. James's Hall Restaurant, and that a capital programme awaits them.

Electrical Power Transmission.—We notice that Mr. Gisbert Kapp, C.E., is to give three lectures at the Society of Arts on this subject on February 16 and 23, and March 2.

Globe Theatre. — Messrs. Dickinson and Co., electricians, of Hanway-street, have secured from Mr. Norman Forbes a contract to install the electric light throughout the Globe Theatre.

Paris (1889) Exhibition.—Dr. Aron's meter has been awarded a gold medal. The agents for this meter in England are the General Electric Company, of 71, Queen Victoria-street, E.C.

Falmouth.—A London syndicate are about to erect a large hotel at Trefusis, Falmouth Harbour, at an estimated cost of about £20,000. It is said that the building is to be lighted electrically.

Finchley.—The Local Board are considering the question of introducing electric fire alarms. A committee has been appointed to report as to lighting the parish by electricity or other means.

Weymersch Battery.—The Weymersch Electric Battery Syndicate has been just formed into a limited liability company with a capital of £20,000. The money has been privately subscribed.

Germany.—It is stated that trials of electric storage cars on the short railway between Hildburghausen, Haldberg, and Friedrichshall have resulted satisfactorily in spite of the fact that the inclines are heavy.

Stuttgart, like many another town, is so overrun with wires for telephonic and lighting work that the administration cannot find room for more unless they go underground. Work has been begun with this object.

Certificates for Engine Drivers.—Mr. Seton-Karr's Bill to provide for certificates to persons in charge of steam engines and boilers on land has been introduced in the House of Commons and read a first time.

Bromley (Kent).—Messrs. Laing, Wharton, and Down have written to the Local Board stating that as the Board are about to apply for a provisional order, they themselves will not proceed with the notice they have given.

Smoking Concert.—The fifth smoking concert of Messrs. B. Verity and Sons will take place to-night. Anderton's Hotel is the meeting place this time, and some interesting and amusing developments are promised.

Blackpool.—The Standard Contract Corporation of London, and the local Aquarium Company are proposing to erect an Eiffel tower at Blackpool. It will be 500ft. high, and will have a turret fitted with a powerful arc lamp.

American Journalism.—The *Electric Railway Advertiser*, published at Boston, is one of the latest productions of the American press, so far as the applications of electricity are concerned. Its name seems to have been well chosen.

Whitechapel.—The District Board of Works decided at a recent meeting to apply for an order. They expect to be able to utilise the heat of their destructor for generating steam up to 100 h.p., with which they would begin their lighting.

Bournemouth.—At the meeting of the Town Council on Tuesday it was reported that the Brush Company intended to place their wires underground. The surveyor having reported on the matter, its further consideration was deferred.

Edison Continental Company.—M. Meyer, civil engineer, who was concerned in the erection of the Halles installation at Paris, has been appointed manager of the Edison Continental Company. He will enter on his duties as from the 1st January.

Australian Cable Guarantee.—A Reuter telegram, dated Dec. 3, says that the Government of South Australia requires that the existing cable tariff shall be maintained for Queensland and New Zealand, or that a guarantee shall be given against possible loss.

City and South London Railway.—The Austrian Minister of Commerce is going to send two engineers to London to study the method of constructing and working this line with a view to utilising the experience so gained in the projected Vienna Metropolitan Railway.

Electric Mining.—At the Standard Tin Mine's meeting the other day, we notice that the chairman reported great progress in their work, and attributed the success achieved in great part to the Immisch electric plant of 25 h.p., which was installed in their mines last year.

Mullingar.—In another column will be found the tenders sent in for lighting Mullingar District Lunatic Asylum by means of electricity. It will be noticed that there is a wide difference between the amount of the highest and the lowest tenders. The accepted tender has not yet been made known.

Salisbury.—Some correspondence has been appearing in the local press in which suggestions have been made

that the town should be lighted electrically. Seeing that Salisbury is favourably situated with regard to the utilisation of water power, the Corporation have a chance of getting their motive power cheap.

The Telephone in Torquay.—The Western Counties Telephone Company are going ahead in this district, and subscribers are increasing. In case of fire in the neighbourhood, on any day except Sunday, all that is necessary is to call up the exchange and shout "fire." The operator at once summonses the brigade, and a great deal of valuable time is saved.

A Luxurious Yacht.—The "Electra," the boat belonging to Commodore Gerry, of the New York Yacht Club, is a model in her way. She has an electric engine, 150 incandescent lights, electric headlight of 15,000 c.p., electric apparatus for firing the guns in starting regattas, ce machine capable of making 50lb. daily, and, in fact, every modern convenience.

Seville.—A central station has been put up here. Belleville boilers are used to generate steam for four Offmann compound vertical engines supplied by the Oerlikon Company, which drive four compound Brown dynamos giving 480 amperes and 110 volts. Underground cables are used, and the switches and other regulating apparatus is by Woodhouse and Rawson.

Glasgow Electric Cars.—It appears that the Glasgow Tramway Company are going to introduce accumulator cars on their lines. The recent action of the Glasgow Corporation has forced their hands, for it would seem to be settled by the authority that if the tramway company do not introduce electricity the Corporation will. Six cars will be tried at first

Royal Institution.—The arrangements before Easter include six lectures on "The Forces of Cohesion," by Lord Rayleigh. The Friday evening meetings will begin on January 23, when Lord Rayleigh will discourse on "Some Applications of Photography." Succeeding lectures will probably be given by Prof. A. Schuster, Dr. J. A. Fleming, Prof. W. E. Ayrton, and others.

Cheltenham.—At a recent lecture given at the School of Science by Mr. H. Matthews, the Western Counties Telephone Company connected the lecture-room with Swansea, Bristol, Llanelly, etc., and also with the offices of the *Cheltenham Chronicle*, a reporter taking notes of the meeting by this means. The usual music playing and conversation went on between Cheltenham and the towns above mentioned.

Hampstead.—The Hampstead Vestry has resolved to oppose all applications from companies or firms for orders. At the same time the Vestry has empowered its Electric Lighting Committee, of which Mr. F. E. Baines, C.B., is chairman, to expend not more than a hundred guineas in obtaining a plan and estimate from a specialist with a view of guiding the Vestry as to the advisability of undertaking the work itself.

Barnsley.—At the last meeting of the Town Council the town clerk submitted the draft of the proposed contracts with the Westinghouse Electric Company, which it was stated provided that, with the exception of engines and dynamos, the materials required should be made in England. The erection of the plant, we learn, has not yet been actually begun, but the preparations are being actively pushed forward.

Nottingham.—The Corporation having obtained an order propose, subject to the sanction of the Board of Trade, to transfer their powers to anyone willing to undertake them. Persons or companies who would wish to do so are asked to send in their names and addresses to the Town Clerk, Guildhall, Nottingham, on or before the 15th inst. An advertisement referring to the matter will be found elsewhere.

Liverpool Electric Cars.—It will be remembered that a very complete test was made over all the Liverpool tram lines with an accumulator car some months ago. The result of this testing seems to have been satisfactory, and a new steel underframe car is now in course of construction at the Metropolitan Carriage and Wagon Works for actual use on the Liverpool roads. The car will be fitted with two motors, one on each axle.

Ferranti Mains.—A very good view of the exterior of the famous Ferranti mains is kept constantly before the eyes of the engineers at the Brush Company's works and visitors thereto. Here the four mains rise from the ground and scale the wall of the Charing Cross railway bridge. Those interested who have an occasion to go to Lambeth, and have not yet seen these mains, may thus have an early opportunity of satisfying their curiosity.

Royal Society of Edinburgh.—The opening meeting of the hundred and eighth session was held on Monday evening, Prof. Sir Douglas Maclagan, the new president, in the chair. Sir Douglas paid a hearty tribute to the retiring president, Sir William Thomson, now P.R.S. While second to none in the ranks of pure science, Sir William Thomson was without a rival in the technical application of some of its most recondite principles, said Sir Douglas.

Old Students' Association Smoking Concert.—A most enjoyable concert was held at the Mason's Hall Tavern, Basinghall-street, on Friday evening, November 28. The programme included violin solos by Mr. Gatehouse; "My Queen," by Mr. Howden Tingey; "Off to Philadelphia," by Mr. John Barton; "The Bedouin's Love Song," by Mr. Gordon Heller; musical sketch by Mr. Charlton Fry, etc. We understand that after Christmas there will be a series of a similar nature, and we hope they will be as successful as the last.

Institution of Electrical Engineers.—The annual general meeting will be held at the Institution of Civil Engineers on Thursday next, at 8 p.m., for the reception of the annual report of the council, and for the election of council and officers for the year 1891. The papers on "The Efficiency of Secondary Cells," and "On the Chemistry of Secondary Cells," by Prof. W. E. Ayrton, F.R.S., vice-president, C. G. Lamb, B.Sc., and E. W. Smith, associates, will be further discussed.

SS. "Silvertown."—This telegraph steamer, owned by the India Rubber, Gutta Percha, and Telegraph Works Company, is reported to have arrived at Coronel (Chili) on November 25. It will be remembered that she carries the submarine cable for extending the Central and South American Telegraph Company's lines from Lima, where they at present terminate, to Yquique and Valparaiso. Later news, dated December 1, from New York says that the "Silvertown" had arrived at Valparaiso.

Nimes and Troyes (France).—The Compagnie Nationale d'Electricité, which has the concession for light

ing Nimes, is about to begin work, and it is hoped that the lights, 2,000 in number, will be running in four or five months. The total station capacity is between 5,000 and 6,000 lamps. The company's station at Troyes, which was opened in August last, supplied current during October to 1,100 lamps on an average, in November about 2,000 lamps were in circuit; 6,000 is the total capacity. The Ferranti system is employed.

Sir Wm. Thomson, P.R.S.—All the world knows that the new president of the Royal Society is Sir William Thomson, who succeds Sir G. G. Stokes. This election will give universal satisfaction to all electricians who speak the English language, for a man more renowned both for practical work and scientific research cannot be named in this or any other tongue. The presidentship of the Royal Society is the very highest honour that can be bestowed upon English scientific men by English scientific bodies, and Sir William Thomson is a worthy recipient of it.

Guttapercha has been rapidly getting dearer as the demand grew, and the supply showed signs of diminution. The tree does not mature quickly, and as it has to be cut down before the juice is extracted, the stock is getting low in spite of planting. We give the quantity imported and its value during the last four years:

1887	24,145 cwt.	£156,563
1888	22,483 „	181,660
1889	48,042 „	576,896
1890 (10 months)	60,494 „	686,013

Gas Engines.—Recent progress has been made in large gas engine plants by Messrs. Dick, Kerr, and Co., who are now building twin double-acting gas engines of 120 brake h.p., to be driven by Dowson's governor, a combination which, as is well known, became a very serious rival to the steam engine both in point of cost and convenience of running. An electric light plant has been lately erected, with one of these engines of 85 brake h.p., in which the governing is so regular and close that any number from two to 600 16-c.p. lamps have been run direct without appreciable variation in light.

The Square Drilling Machine.—The statutory meeting of the shareholders in the Square Drilling Machine Company was held a day or two since. The chairman, among other things, mentioned that they had appointed Mr. Claridge as their manager, and that he had visited the chief engineering centres in the provinces and had obtained orders to an extent which showed they were earning rather more than would pay for working expenses. They had already obtained 15 orders, two of which were for the French Government. We described and illustrated this machine in our issue for July 18 (No. 3, Vol. VI.).

The Edinburgh Exhibition.—A committee of the Dundee Town Council is considering to whom it shall pay its £200 guarantee. The British Linen Bank and the exhibition liquidator both want it, but Dundee is not going to pay twice, and the committee won't hand over until they are secured from such an undesirable result. Messrs. A. Drysdale (one of the building contractors), Mr. A. B. Brown (of King, Brown, and Co.) and Mr. N. Grieve, of Edinburgh, have been appointed a committee of creditors, with whom the liquidator, Mr. J. A. Robertson, can consult. The exhibition buildings are to be taken down in sections and sold by auction from time to time.

The Extension of the Telephone.—The following paragraph from a Scotch paper may be taken as the first signs of the coming fight: "During the last three weeks Mr. A. Erskine Muirhead, Cart Forge, Crossmyleef, has been erecting long stretches of wire in Yorkshire, Lancashire, London, Belfast, and Glasgow and neighbourhood, to which he will attach the new French telephones at the beginning of next month. Mr. Muirhead is also making arrangements to connect, by direct private wires, a large number of coal pits in the Motherwell, Hamilton, and Wishaw district with the offices in Glasgow. Inter-communication is being established in many large places of business. The insulators and battery are of French manufacture."

Phosphorus Works.—The new works at Wednesfield for the manufacture of phosphorus by the Electrical Construction Corporation's process are now practically completed. A trial run of the machinery last week gave satisfactory results. The works consist of boiler-house, engine and dynamo-house, retort-room, and battery-house. There are three Babcock, Wilcox, and Co.'s tubular boilers, into which the water, supplied from a large private tank, is pumped by two Worthington pumps after passing through an economiser. The engine, one of Yarrow's, is of 700 h.p., marine type, and similar to those in use on torpedo boats. The machinery consists of a 400-unit alternating dynamo, which is excited by an 18-unit dynamo. This also charges the accumulators, by means of which the works are lighted.

Edinburgh.—The following is the compulsory area under the Corporation's order, as given in their "notice of intention"—viz.: Abercromby-place, Ainslie-place (south-eastern portion), Atholl-place, Chambers-street, Charlotte-square (north and east sides), Charlotte-street (south), Coates-crescent, Coates-place, Darnaway-street, Drumsheugh-gardens (from Rothesay-place to Drumsheugh-place), Drumsheugh-place, Erskine-place, Forrest-road, George-street, Glenfinlas-street, Great Stuart-street, Greyfriars-place, Heriot-row, Lindsay-place, Maitland-street, Melville-place, Moray-place (from Great Stuart-street to Darnaway-street), North Bridge, Palmerston-place (from Coates-place to Rothesay-place), Princes-street, Queensferry-street, Randolph-crescent (southern portion), Rothesay-place, St. Andrew's-square, Shandwick-place, South Bridge (from High-street to Chambers-street).

Leeds.—The Corporate Property Committee has resolved "that stock be taken of all plant, loose articles, engine, dynamos, globes, and leads, both in stock and in the Town Hall and Municipal Buildings, at its present value as a going concern; that the balance of the money granted to the Electric Lighting Committee be placed to the credit of this committee; that the Fine Art Gallery, the rate offices, and the several offices in the Municipal Buildings have a correct account taken of the number of lamps in each department; that a correct account be kept of all wages and expenses of everything connected with electric lighting, and that, so far as possible, an account shall be taken of the number of hours the lights in each room are burning and the number of burners in each room; and that a debit and credit account be formed, so as to arrive as near as can be at the cost of electricity per lamp per hour."

Ship Lighting.—The "Gera," built for the Norddeutscher-Lloyd Company of Bremen, 5,400 tons, is lighted throughout by means of electricity; so is the "Tosari," built for the Deutsch Dampfschiff's Rhederei of Hamburg; and the "Naiad," second-class cruiser for the Government, launched from the yard of the Naval Construction and Armament Company, of Barrow, the third from the same works, on Saturday last. The Red Star liner "Indiana" has ust

been overhauled by Messrs. D. and W. Henderson, Partick. A complete installation of electric light has also been fitted up by Messrs. J. H. Holmes and Co., Newcastle-on-Tyne and Glasgow. The installation consists of 122 16-c.p. incandescent lamps, supplied from one of Messrs. Holmes's slow speed dynamos, coupled direct to a vertical engine running at a speed of 300 revolutions per minute. All the wire used is covered with lead sheathing.

Street Lighting.—The *Journal of Gas Lighting* says: "The true standard of sufficiency in street lighting, beyond which extravagance commences, varies in different places mainly according to the amount of traffic; but while difficult to define, it is easy to realise. Lighting which enables foot passengers to make their way quickly and safely along side walks, and especially to cross roadways with fair assurance of security, is good enough for its purpose." The first sentence is general enough to pass. But we don't find that the definition contained in the second sentence has yet been learned by gas engineers. The lighting of our suburban streets is of that negative kind which is said to make darkness visible. Foot passengers certainly cannot be said to be able to cross roadways in suburban London with even a "fair assurance of security" (we pause to point out the qualifying adjective), so unutterably deficient is the light there provided.

Lighting and Traction in Italy.—A peculiar installation for lighting and traction was opened a few weeks ago between Pazzala and Lugano, in Italy. A waterfall supplies the water conducted through iron pipes to the generating station, where two Girard turbines of 300 h.p. each drive two dynamos, one for continuous and the other for alternating current, the former working the tramway motor, the latter supplying 1,500 glow lamps of 16 c.p. each at the hotel, the tramway line, and at private buildings. The double track is one mile in length, and is worked by a cable 1·3in. diameter, supported by wooden rollers, one branch of the cable attached to the ascending, the other to the descending car, each of them weighing 4½ tons. The generating dynamo gives 60 h.p. at 1,800 volts, and 22 amperes for 700 revolutions per minute. The electric motor for the cable produces 40 h.p. at 700 revolutions, so that the efficiency of the transmission will be 66 per cent., the conductor being an overhead wire 0·2in. diameter, carried on oil insulators. A spare steam plant of 50 h.p. is provided in case of failure of water supply.

Paddington.—At a recent meeting of the Vestry, Colonel Barchard, C.B., presented a report of the Electric Lighting Committee, and, in answer to a question, explained that if the Metropolitan Electric Supply Company did not comply with the provisional orders they were liable to a forfeiture of a certain amount of money. They had deposited £20,000, and had taken a site at St. Peter's-park, Amberley-road, at a cost of £6,500, and the machinery would come to another £7,000. They wanted this £13,000 deducted from the £20,000 as a set-off, but the committee thought that in the interests of the parish this should not be, as there would be no guarantee should the site be used for any other purpose than for lighting Paddington, but whatever the Vestry did, the Board of Trade had the power to withdraw the concession to the company if they did not carry out the provisions. He was pleased to inform the Vestry that the £20,000 had been lodged. The solicitor had also drawn up the agreement, and he would ask the Vestry to affix the seal to the same. The report and agreement were accepted and entered on the minutes.

Theatre Lighting.—On Monday night, December 1, a new theatre of varieties, the Empire, was opened in Newcastle-upon-Tyne. The electric installation is by Messrs. R. J. Charlton and Co., of that town. In the centre dome of the auditorium is a handsome gilt electrolier of 21 32-c.p. lamps, and in the form of spandrels round the dome are four other electroliers to match the centre, each having three 50-c.p. lamps. Over the promenade, balcony, and in the private boxes are suspended wrought-brass suspensions with amber shades, which give a rich and soft light. Round the back of the pit and balcony are placed 24 two-light brackets, and in the front of the balcony are three-light brackets, the whole being gilded to match the other fittings. The various refreshment-rooms, staircases, and offices have similar fittings. The footlights consist of 18 25-c.p. lamps in enamelled iron parabolic shades. Instead of limelights there are two automatic mirror arc lamps. The whole of the lights in the house are controlled from a switchboard on the stage. The lessees of the theatre express themselves as highly pleased with the installation, which is said to have been very satisfactorily carried out by the contractors.

Heckmondwike (Yorks.).—A special meeting of the Heckmondwike Local Board was held on Monday night, to consider whether the Board should apply for an order. The report of the committee appointed to enquire into the matter was read, showing the total outlay for plant, etc., would be about £3,600, whilst the cost of maintenance would be slightly under the cost of gas at double the present standard of illuminating power. No recommendation was made, but a lot of statistical information was given, showing the successful working of the light in other towns. A resolution was moved and seconded that the necessary powers be applied for. The contention of the supporters of the resolution was that the Board should possess the power, and then they would be in a position to allow any private company to undertake the carrying out of a scheme, or carry one out themselves, if necessary. There appeared to be no disposition to enforce the adoption of a scheme, the only desire being to get an order enabling the Board to deal with the matter. After some discussion, during which an amendment was moved and seconded, but not carried, the motion was withdrawn in favour of one adjourning the matter until next Monday, when it will be again considered.

Overhead Wires and Subways.—In a petition presented to the Local Government Board by the Strand Board of Works, the petitioners contend that the public interests require that the control over the streets and pavements shall be so vested in the various local authorities in the metropolis as to enable them to make proper regulations as to the breaking up or disturbing of the streets and pavements in their several districts. With regard to subways, it is urged that further powers should be conferred for making and maintaining other subways in streets, and that provisions should be made requiring that such subways should be used for the reception of pipes, wires, and the like, instead of such streets being from time to time thus broken up and interfered with. The petitioners also complain of the danger and inconvenience arising from overhead wires and cables owing to their being no efficient system of control or regulation, and ask for additional powers to enable them to deal with the same. They ask that all the above suggestions may be embodied in any Bill that may be introduced into Parliament for the creation of district councils, and that such

district councils should be the local authority for the purposes aforesaid.

Compressed Hide Gearing.—By a further development of the compressed hide process for making gear wheels, Mr. T. Taylor, of Manchester, can now produce wheels up to any size within practical limits. For the larger gears the body of the wheel is constructed of iron or steel. On the face of the wheels dovetails are cut at the required intervals to receive teeth manufactured of raw hide, these being forced into dovetails by hydraulic pressure, the teeth passing from edge to edge of the face. After the teeth have been forced into position they are cut to the exact pitch required, and then on each side of the wheel a steel rim shrouding the teeth is secured by steel pins to each tooth, this rim being otherwise loose on the wheel. The advantage of this arrangement is that the pressure on any particular tooth is distributed by means of the rim over the whole of the teeth, which, from the nature of the material out of which they are manufactured, possess a slightly elastic character. The first wheel of this kind that has been produced has just been turned out for the Electric Traction Company, to be used as the main driving wheel on one of their tramcars. This wheel is 1in. pitch, with a 2¾in. face, and is 2ft. in diameter. The firm have enquiries for similar wheels up to very much larger sizes than this.

Birmingham.—The Public Works Committee are considering, amongst other matters, notices of intention to apply for orders by the Birmingham Electric Supply and the House-to-House Company. The former wish to enlarge their area by including Moor-street, Bull Ring, and Stephenson-street. The latter have amended their order so as to exclude that part of the town already supplied by the other company. It is stated that a large portion of the Council feel that the Supply Company should not be interfered with in their venture, and that if the results of the lighting in their portion of the city should prove satisfactory, any further extension of electric lighting should be carried out by the Corporation, and not by private companies. At a recent meeting of the Town Council, the Mayor remarked that they had made a concession to a *bonâ fide* local company, which was getting on very successfully. A plant was being put down for 5,000 lights, 1,700 had been already let, and negotiations were in progress for the letting of others. The electric light would be an accomplished fact in Birmingham before the end of January. We may echo the hope of a member of the Council—namely, that motors won't be far behind the light. There ought to be a wide field for their employment in Birmingham. The central electric light station at Birmingham is now progressing rapidly. The roof is now on and three of the engines are being fixed. The mains have been under process of laying for some time, and it is hoped that lighting may be commenced soon after Christmas.

New Cables.—A fourth cable has been laid by the Eastern Telegraph Company from Suez to Aden, a distance of 1,400 miles, and by May next a third cable will be laid from Aden to Bombay, a distance of close on 2,000 miles. The Eastern Extension has duplicated its cable from Madras to Penang, which are 1,500 miles apart. There are now three cables between London and Australia, two extending from Java to Port Darwin, and the third, which was laid last year, from Java to Roebuck Bay. Besides these extensions, negotiations, says the *Pall Mall Gazette*, are in progress for the laying of a cable to connect Madagascar and the Mauritius with the Eastern and South African Company's cable at Zanzibar. (This was mooted several years ago.) On the coast of South America the Western and Brazilian Company are doubling the line from Rio de Janeiro to Buenos Ayres, and nearer home we have just had 600 miles of new cable laid by the Great Northern Company between the North of England and Sweden. Business is being done more and more by telegraph, and as it must be compressed into a few hours each day this multiplication of cables becomes a necessity. All the American messages, for instance, are confined practically to six hours out of the 24, and for the other 18 the cables may be said to lie idle. While they are at it it is a rush. Messages and replies cross and recross the Atlantic in a few minutes at that busy time of the afternoon, when the Stock Exchanges of London and New York are feeling each other's pulses, and the arbitrage dealers are striving to grasp the turn of the market. From the Far East and Sydney it is possible to get a message through in a quarter of an hour, but in practice the time is about three hours. The aim is to have all the business through by four or five o'clock, so that the senders may have replies before them in the morning.

The Royal Society.—The anniversary meeting of this society was held on Monday at Burlington House, when the president and the council for the ensuing session (the list will be found in our Notes of November 14) were elected. The retiring president referred to the Joule Memorial, and said that the treasurer of the committee had handed over to the Royal Society about £1,400. He expressed his strong regret at the closing of his official connection with the society, which had lasted 36 years, during five of which he had been its president. He then presented medals to the following among others: Dr. Hertz, the Rumford medal, for researches in electromagnetic radiation; and Dr. John Hopkinson, a Royal medal for researches in magnetism and electricity. In the evening the usual dinner was held at the Hotel Metropôle, the new president, Sir William Thomson, in the chair. In responding to the toast of "The Royal Society," Sir William said it was indeed the crown of his life to be called on to reply on behalf of the society, which had now been before the world for 250 years as the great promoter of science in the United Kingdom. He would not forget, however, in the presence of the Italian Ambassador, that it had been preceded by scientific institutions in Italy, the Academia of Florence, and the various societies which followed the teaching of Galileo. Having referred to the earlier history of the society and Newton's connection with it, Sir William concluded by expressing his appreciation of the high honour conferred upon him in making him the successor of Sir Gabriel Stokes. He then proposed the "Medallists." Dr. Hopkinson was the first to reply to this, and said that, referring to our confrères on the Continent, if he had been obliged to obtain the sanction of a Government Department to make experiments, or to make them in a licensed place, it was very little experimental work he could have done, and he should not have been in the proud position of one of the medallists that evening. He owed to Sir William Thomson, who had been the kindest of friends, the first impulse to experimental work in electricity and magnetism. Dr. Hertz also responded to the toast, and paid a tribute to Prof. Lodge, of Liverpool, and other investigators in the same line of research.

NOTES ON ECONOMY IN CONDUCTORS IN SYSTEMS OF DISTRIBUTION OF ELECTRICAL ENERGY.*

In considering what economies it is possible to introduce into a system of conductors laid down for the distribution of electrical energy, one has at the outset to consider the relative merits of the different systems which have been proposed before investigating the best proportions to be given to different parts of the system fixed upon, and the proper current densities to be employed in them.

With regard to this first question, I do not propose to say more than a very few words, or to deal with it in any but the most general way.

It is important to observe, in the first place, that the pressure to be used in houses for lighting by incandescence lamps has been practically limited to a maximum of 100 to 120 volts by the makers of the lamps, and that the pressure in buildings may not in any case exceed the 300 volts fixed by the Board of Trade. This consideration, while greatly hampering the system of simple parallel distribution, does not affect to any great extent the rival systems employing accumulators or secondary generators.

In his Cantor lectures before the Society of Arts in 1885, Prof. George Forbes gave a very interesting account of various systems and their sub-divisions; and he showed that, except for a very limited area of compact form requiring a large amount of light per unit of area, this system of simple parallel distribution is impracticable on account of the enormous expense of mains to carry the large currents necessitated by the use of so low a voltage. For a very small and compact area such a block of buildings, it may be worth while to consider the applicability of this system, however, on account of its simplicity and the cheapness of the class of cable that may be employed.

No practical use of the series system for general station work has been made that I am aware of, though, of course, it is largely in use for outdoor lighting and transmission of power. It has the obvious advantage of requiring comparatively small conductors, but against that must be put the expenditure necessary for providing a complete system of automatic cut-outs for every lamp, motor, or other apparatus employed, and the difficulty of regulating with any reasonable degree of economy for the varying numbers of lamps alight on different circuits. The comparatively low efficiency of glow lamps for series lighting is also an important reason against the adoption of such a system.

The next system to which attention may be drawn is the series-parallel system, of which the modifications known as the three-wire, four-wire, and similar systems are the most important. These are in general use both in England and abroad, and give for certain distributions of lamps a very good result indeed.

The degree of economy to be obtained with a three, four, or n wire system over the simple parallel system depends on the certainty or otherwise with which you can rely on a continued balance of load between the different sections. This you would secure as far as possible by putting as many of each class of consumers in each section, and also, if practicable, by insisting upon the wiring of all buildings supplied being upon the same system as that of the mains, and the total load in every case distributed between the sections.

If you are sure that the load in any one section will never exceed that of any of the others by more than m per cent. of the full load of a section, and the system is one of n wires; then, if E stands for the percentage reduction in amount of copper used from that necessary in an equivalent simple parallel system,

$$E = 100\left\{1 - \frac{200 + m\,(n-2)}{200\,(n-1)}\right\}$$

For example, let $m = 25$ and $n = 3$

then $E = 43{\cdot}8$.

If, as in a case in which all the wiring is done upon the same system as that of the mains, we may take $m = 10$; and supposing $n = 4$, then

$$E = 63{\cdot}3.$$

If in the same case we take $n = 5$,

$$E = 71{\cdot}3.$$

In considering these systems it is necessary, in any practical case, to take into account the increased cost of labour in putting them down, and of the conduits or pipes in which they are enclosed. In connection with this, it is worthy of remark that with underground systems of mains —such as are likely to be in vogue in future—the cost of the actual cables may amount to less than 50 per cent. of the total cost of the cables laid.

With regard to systems employing accumulators or secondary generators, there is at once a great gain in the allowance of very much high pressures in the mains. The cable is, however, very much more expensive, and the cost of the accumulators and their constant inefficiency must be taken into account in the one case, and in the other the cost of the converters and their inefficiency on light loads. In the case of accumulators it is necessary to distribute the energy from sub-stations upon some one of the low-tension systems, so that there is only a partial gain in respect to copper; and with converters, and especially those for alternating currents, it is well known that their cost per kilowatt output diminishes to a considerable extent as their size increases, so that with these also it may be and is advisable sometimes to employ sub-stations, so that the same remark will apply here.

I have now very briefly alluded to some of the conditions affecting the relative economies of the chief systems of distribution of electrical energy; and I have purposely refrained from examination of them in detail for the reason that every particular case will differ to some extent from any other, and in making a choice of the system to be employed to best meet its requirements, a special investigation should be made having regard to all the conditions involved.

Before taking up any problems such as those referred to in the abstract sent out to members, a word must be said as to the relation of price to size of cable. Bare wires, as you all know, are sold at so much a pound in general; stranded cables being a little more expensive than single wires, and wires smaller than No. 20 or 22 a little dearer than those above this size. Speaking generally, however, cables of bare wire of approximately the same cross-sectional area are sold at the same price per pound. Small insulated wires of a definite thickness of insulation, such as one of two layers of cotton or silk, are also often sold at so much a pound, but with these we have nothing at present to do, unless it be to remark that with such wires the insulation resistance necessarily decreases as the wire increases in size.

Insulated cables for use in any of the cases we have to consider are, I believe, invariably sold by length.

For a given class of insulation, and a given insulation resistance per mile, you would expect—seeing that for a given insulation the mass of the insulator is directly proportional to the mass of the copper insulated—that the prices should be very nearly proportional to the cross-sectional areas of the copper conductors. In practice this is very nearly so, for the price of a cable may be expressed by the equation

$$P = a + b\,A,$$

where P = cost per mile in pounds

A = area of conductor in $\frac{1}{1000}$s of one square inch and where a and b are constants depending upon the class of insulation and the number of strands in the cable, with considerable accuracy with the cables of some of the best known makers.

Taking Silvertown cables for example :

Class L.

7 strands	$P = 10{\cdot}3 + 3{\cdot}58\,A$	within	2·6 per cent.
19 „	$P = 15{\cdot}7 + 3{\cdot}39\,A$	„	3·5 „
37 „	$P = 22{\cdot}5 + 3{\cdot}32\,A$	„	0·7 „

Class D.

7 strands	$P = 4{\cdot}72 + 1{\cdot}32\,A$	„	2·9 „
19 „	$P = 7{\cdot}22 + 1{\cdot}27\,A$	„	4·6 „
37 „	$P = 12{\cdot}2 + 1{\cdot}25\,A$	„	0·4 „

* Paper read before the Old Students' Association, by Hamilton Kilgour, member.

The percentage errors given above are the maxima, and the average are from $\frac{1}{3}$ to $\frac{1}{2}$ these.

In a similar way the values of the constants for the other classes manufactured by the Silvertown Company may be tabulated, but I have not thought it necessary to do so here, more especially as I have not their most recent price-sheet by me.

With Fowler-Waring cables (lead covered) you would not expect this law to hold with the same degree of accuracy, as the thickness of lead is not proportional to the diameter of the cable. We have, however, for seven-stranded cables $P = 25{\cdot}9 + 2{\cdot}49\,A$, with a maximum error of $12\frac{1}{2}$ per cent. and an average error of 4·8 per cent.

The cables of Messrs. Siemens are not manufactured upon the plan of having a given insulation resistance per mile for a given class of cable; the insulation resistance of their cables of a given class diminishes as the size of the cable increases. For example, for their classes L, M, and N, the insulation resistance per mile varies from 2,500 megohms for the smallest sizes to 300 megohms for the largest. You would not, then, expect to find the price of a cable proportional to its size, nor, in fact, is it actually nearly so.

With all cables, however, which are very nearly of the same size the price is, of course, very nearly proportional to the cross-sectional area of the copper, and over a narrow range the rule $P = a + b\,A$ still holds, the constants in any case being very easily determined by plotting a few points in the neighbourhood of the size you want, and drawing the tangent to the curve (or the chord through points on either side of the size you estimate is about what you require) when the ordinate of the point of intersection of this tangent or chord with the axis of y gives a, and b is the trigonometrical tangent of the angle made by the line as drawn with the axis of x, it being supposed that prices are plotted as ordinates.

Now, in any case of central station work you can estimate from experience what is approximately the cross-sectional area of copper you want, so that we may take it that, for our purposes, the rule $P = a + b\,A$ holds universally. This may be regarded in the light that you pay a sum a for the privilege of being allowed to buy the cable you require from the makers you are dealing with, and for the rest the price of this cable is directly proportional to its size.

The most economical current density to employ for a constant and uniform current circuit working for a given number of hours per annum.

Let a = current in amperes;
n = number of hours of working per annum;
ρ = resistance of conductor of one square inch sectional area in ohms per mile;
c = value of the Board of Trade unit in pence;
d = sum of the rates of interest, depreciation, and repairs on capital laid out in cable;
x = sectional area of conductor required in $\frac{1}{1000}$s of one square inch;
D = most economical current density to employ in amperes per square inch;
P = $a + b\,x$ as before;

then
$$x = a\sqrt{\frac{n\,c\,\rho}{2{\cdot}4\,b\,d}}$$

and
$$D = 1{,}000\sqrt{\frac{2{\cdot}4\,b\,d}{n\,c\,\rho}}$$

For copper conductors $\rho = 0{\cdot}0425$, hence

$$x = 0{\cdot}133\,a\sqrt{\frac{n\,c}{b\,d}}.$$

and
$$D = 7{,}513\sqrt{\frac{b\,d}{n\,c}}$$

For example, if we take Silvertown class L cable, and

$$c = 5$$
$$d = 13$$

we shall have the most economical current densities for different numbers of hours per annum given by the following table.

n	D.		
	7 strands.	19 strands.	37 strands.
400	1,119	1,089	1,077
600	913	889	880
800	791	770	762
1,000	708	689	681
1,500	578	562	556
2,000	500	487	482
3,000	408	398	393

In this table ρ has been taken as 0·0446, which is rather higher than it should be.

No account of the increased resistance of the conductor due to heating has been taken account of in the foregoing; but as the current density to employ in a given case is known approximately from previous experience after a little, an allowance can easily be made for the probable heating in the value of ρ you decide to use.

Variable but Uniform Current Circuits.

If the current in a circuit is not a constant quantity—as in the case of series arc lighting—but variable throughout each day, and from day to day throughout the year, the value previously obtained for the most economical current density to employ refers to the square root of the mean square of the current for the year. In estimating or planning a system of mains it is more convenient to think about the most economical current density referred to the maximum current; that is to say, it is better to know that the greatest economy will be obtained in a given circuit if the current density, when the maximum current is flowing in it, is, say, 500 amperes per square inch, than to know that you obtain the most economical arrangement if the current density of the square root of the mean square of the current is, say, 300 amperes per square inch.

It is necessary, then, to consider what the ratio of the maximum current to the square root of the mean square of the current is likely to be in a given circuit; and the best way to arrive at this value is by examination of load diagrams obtained from similar districts.

When Prof. Forbes, in 1885, so strongly advocated the most thorough and careful working out of any system of mains to be laid down in order to obtain the most economical arrangement possible, electrical engineers were necessarily very much in the dark as to the data upon which to base their calculations. It is absolutely essential, in order to plan the most economical arrangement possible, to know beforehand what kind of load diagram you are likely to get. Fortunately, we have now a certain amount of experience to help us, but there is no doubt that in this respect the experience of the next 10 years will be most valuable.

I have worked out one or two load diagrams for a single day in order to give an example. For this diagram, which was taken at Boston, the ratio of the maximum current to the square root of the mean square works out to 2·34, and for this second diagram, which was sent out by a town in the West of England in order that maintenance estimates might be prepared, the ratio is 3·57, and for this third diagram the ratio will be between 2·5 and 3·0.

With a slide-rule and planimeter it is, of course, a very easy matter to determine this ratio for any given load diagram. The value to be used, however, is that obtained from a complete set of diagrams taken at short intervals throughout the year, and in connection with this it may be mentioned that Dr. Gustav Rasch states that the value of this ratio (as obtained by observations at different central stations during one year, and taking the average value) is 3·41.

To take an example, let us suppose that the cost of a Board of Trade unit is 3d., that the sum of the rates of interest, depreciation, etc., is 15 per cent., that current flows throughout the year in the circuit under consideration, that the ratio of the maximum current to the square root of the mean square is 3·2, and that the cable is 19-stranded Silvertown L. We have thus

$$b = 3{\cdot}39$$
$$c = 3$$
$$d = 15$$
$$n = 8760$$

hence $$D = 3{\cdot}2 \times 7{,}513 \sqrt{\frac{3{\cdot}39 \times 15}{8{,}760 \times 3}} = 1{,}058$$

In this case, then, the most economical current density is 1,058 amperes to the square inch for the maximum current.

This determination of the most economical current density to employ for a given type of cable applies only to cases in which the current density is uniform throughout the cable under consideration. This is so, of course, in feeders, but not in the mains proper of a system of parallel distribution.

In the latter case the current flowing across any section of the conductor diminishes as the distance of the section under consideration increases from the feeding points. If we assume that in the mains between two pairs of feeding points the current taken off per yard is constant, we can determine a multiplier for the most economical current density, obtained on the assumption that the current is uniform between the feeding points, which will give us what is really the most economical (maximum, or at a section very near the feeding points) current density to employ in the mains.

In the case we have supposed it is easy to see that this multiplier is $\sqrt{3}$ or 1·732. Now if we take, as before, 19-stranded Silvertown L cable, and make the same assumptions as to the cost of energy, etc., we find that the proper size of main to employ is that which gives us a current density of 1,832 amperes to the square inch at a section very close to the feeding points, and when the maximum current is flowing.

In the case of any other law according to which the current taken off per yard may vary, it is very easy by constructing, firstly, the curve of flow of current along the main, and secondly, the curve of the squares of the current, to deduce the proper multiplier by means of a planimeter and slide-rule.

The process of making the foregoing calculations for any particular case is certainly easy and very fairly rapid, but it is obvious that before attempting to design a set of mains for a particular district, a thorough canvass should be made to ascertain its special requirements.

It should be remarked that the preceding investigation as to the effect of non-uniformity of current in the mains assumes that the load diagrams for the different buildings supplied between two pairs of feeding points are similar in character, a case which in general does not occur in practice, but for which allowance must be made either in the selection of an average load diagram or subsequently by special calculation.

I may end this portion of these notes by observing that though the current density arrived at may seem sometimes rather great, it occurs for such a very limited time that it is not likely to be harmful to the cables used.

Transmission of Power to Stationary Motors.

The whole of the foregoing relates to general supply of energy from central stations, and the conclusions arrived at were all based upon the fact that in such work you have to maintain a definite pressure at the consumers, so that the current to be supplied is a fixed quantity.

As is very well known, Sir William Thomson first pointed out, in 1881, that in such cases the current density to be employed is independent of the length of conductor through which the energy is to be transmitted, and that the proper gauge to employ for a definite current is that which makes the value of the annual waste of energy per mile equal to the interest, depreciation, etc., on the capital laid out in conductor per mile.

There are, however, a large number of cases to which the above does not apply at all, and the transmission of power from a source where it is cheap to a distant point where it is valuable is one of the most important of these at present.

In a very important paper read by Profs. Ayrton and Perry before the Society of Telegraph Engineers and Electricians, the authors gave, among other things, the solution of the following problem: What is the most economical current density to employ when a certain power P has to be furnished at the end of $\frac{n}{2}$ miles, and when the pressure at the source has been fixed at V volts?

If C is the current in amperes, r the resistance of the conductor per mile in ohms, t a constant—depending on the number of hours of working per annum, the cost of the cable per pound of copper, the sum of the rates of interest, depreciation, and maintenance, and the value of a Board of Trade unit—and F(C,r) the total waste of energy per mile reckoned in watts (*i.e.*, with the interest, depreciation, etc., on the cable expressed in watts as well as the actual waste of energy in the cable), we have

$$F(C, r) = C^2 r + \frac{t^2}{r} \quad . \quad . \quad . \quad . \quad . \quad \text{(i.)}$$

and further, $f(C, r) = P - C(V - n C r) = 0 \quad . \quad . \quad \text{(ii.)}$

From these two equations we have to determine C and r, and hence the current density D, so that F (C, r) is a minimum.

As you know, the values of C and r, which make F (C, r) a minimum, are those obtained from the equations

$$\left(\frac{dF}{dC}\right) \cdot \left(\frac{df}{dr}\right) - \left(\frac{dF}{dr}\right) \cdot \left(\frac{df}{dC}\right) = 0 \quad . \quad \text{(iii.)}$$

and $$f(C, r) = P - C(V - n C r) = 0 \quad . \quad \text{(ii.)}$$

From these we obtain

$$C = \frac{P}{V} \frac{n t + \sqrt{(V^2 + n^2 t^2)}}{\sqrt{(V^2 + n^2 t^2)}} \quad . \quad . \quad . \quad \text{(iv.)}$$

and $$D = 23{\cdot}5 \frac{V t}{1 + \sqrt{(V^2 + n^2 t^2)}} \quad . \quad . \quad . \quad . \quad \text{(v.)}$$

the constant 23·5 being the conductivity of a copper conductor one mile long of one square inch sectional area.

If we put $\frac{n t}{V} = \tan \phi$,

$$C = \frac{P}{V}(1 + \sin \phi). \quad . \quad . \quad . \quad . \quad \text{(vi.)}$$

and $$D = 23{\cdot}5 \frac{V}{n}\left(\frac{\sin \phi}{1 + \sin \phi}\right) \quad . \quad . \quad \text{(vii.)}$$

I have calculated the following table of values of $(1 + \sin \phi)$ and $\left(\frac{\sin \phi}{1 + \sin \phi}\right)$ for values of $\tan \phi$ between 0·025 and 4·0, thus embracing all practical cases, I believe. (See Table A.)

From this table, or from the curves given which have been constructed from it, it is a very easy matter to determine the proper current density to employ in any given case without any further calculation than that readily performed with a slide-rule.

With regard to t, its value is obtained from the equation

$$t = 93{\cdot}6 \sqrt{\frac{L\,Q}{N\,U}},$$

where

L = cost in pence in copper in cable per pound.
N = number of hours of working per annum.
Q = sum of the rates of interest, depreciation, and maintenance on capital laid out in cable.

and

U = cost in pence of a Board of Trade unit.

If L = cost in £ of copper in cable per ton, the equation becomes

$$t = 30{\cdot}6 \sqrt{\frac{L\,Q}{N\,U}}.$$

I have thought it of interest to members that tables and curves showing the effects produced in a particular case of varying the different quantities, t, V, and n, should be given, and I have therefore taken the following cases:

(i.) V = 2,000 volts.
n = 10 miles.
t variable between 15 and 50.

(ii.) n = 10.
t = 25.
V variable between 500 volts and 10,000 volts.

(iii.) V = 2,000 volts.
t = 25.
n variable between ½ mile and 50 miles.

And lastly,

(iv.) V = 5,000 volts.
t = 25.
n variable between one mile and 500 miles.

TABLE A.—Transmission of Power.

tan ϕ.	$1+\sin\phi$.	$\dfrac{\sin\phi}{1+\sin\phi}$.	tan ϕ.	$1+\sin\phi$.	$\dfrac{\sin\phi}{1+\sin\phi}$.	tan ϕ.	$1+\sin\phi$.	$\dfrac{\sin\phi}{1+\sin\phi}$.
0	1·0000	0·0000	0·6	1·5145	0·3397	1·8	1·8742	0·4664
0·025	1·0250	0·0244	0·7	1·5734	0·3644	1·9	1·8849	0·4695
0·05	1·0499	0·0471	0·8	1·6246	0·3845	2·0	1·8945	0·4721
0·075	1·0748	0·0696	0·9	1·6689	0·4008	2·2	1·9104	0·4765
0·1	1·0995	0·0905	1·0	1·7072	0·4143	2·4	1·9231	0·4800
0·15	1·1482	0·1291	1·1	1·7402	0·4254	2·6	1·9333	0·4828
0·2	1·1961	0·1640	1·2	1·7680	0·4344	2·8	1·9417	0·4850
0·25	1·2425	0·1952	1·3	1·7924	0·4421	3·0	1·9487	0·4868
0·3	1·2874	0·2232	1·4	1·8137	0·4486	3·3	1·9570	0·4888
0·35	1·3303	0·2483	1·5	1·8319	0·4541	3·6	1·9635	0·4907
0·4	1·3713	0·2708	1·6	1·8482	0·4589	4·0	1·9701	0·4924
0·5	1·4472	0·3090	1·7	1·8619	0·4629	∞	2·0000	0·5000

Transmission of Power.

(i.) P=87,700 watts. V=2,000 volts. n=10 miles.

t.	C.	D.	P_1.	P_2.	P_3.	K.
15	47·13	351·4	6,559	7,619	14,178	7·0
20	48·21	467·9	8,726	10,655	19,382	9·0
25	49·29	582·7	10,878	13,958	24,836	11·0
30	50·35	696·8	13,009	17,542	30,551	12·9
35	51·41	809·8	15,118	21,415	36,533	14·7
40	52·45	921·3	17,199	25,591	42,790	16·4
50	54·48	1,139	21,270	34,892	56,162	19·5

(ii.) n = 10. t = 25.

V.	C.	D.	P_1.	P_2.	P_3.	K.
500	253·8	524·5	39,220	102,681	141,901	30·9
750	153·9	556·6	27,732	53,386	81,118	24·0
1,000	109·0	569·4	21,270	34,892	56,162	19·5
1,500	68·08	579·1	14,418	20,091	34,509	14·1
2,000	49·29	582·7	10,878	13,958	24,836	11·0
3,000	31·66	585·3	7,283	8,602	15,885	7·7
4,000	23·29	586·2	5,471	6,198	11,669	5·9
5,000	18·42	586·7	4,380	4,840	9,220	4·8
7,500	12·08	587·1	2,922	3,123	6,045	3·2
10,000	8·99	587·3	2,192	2,304	4,496	2·4

(iii.) V=2,000. t=25.

n.	C.	D.	P_1.	P_2.	P_3.	K.
·25	43·99	587·2	274	276	550	0·3
·5	44·12	587·2	548	555	1,103	0·6
1·0	44·40	587·1	1,096	1,124	2,220	1·2
2·0	44·95	587·0	2,192	2,304	4,496	2·4
4·0	46·04	586·5	4,380	4,840	9 220	4·8
6·0	47·13	585·6	6,559	7,619	14,178	7·0
8·0	48·21	584·3	8,726	10,655	19,381	9·0
10·0	49·29	582·7	10,878	13,958	24,836	11·0
15·0	51·93	577·1	16,162	23,465	39,627	15·6
20·0	54·48	569·7	21,270	34,892	56,162	19·5
25·0	56·93	560·5	26,158	48,397	74,555	23·0
30·0	59·25	549·9	30,794	70,306	101,100	26·0
35·0	61·43	538·0	35,152	82,181	117,333	28·6
40·0	63·46	525·3	39,220	102,680	141,900	30·9
45·0	65·35	511·9	42,996	125,700	168,700	32·8
50·0	67·09	498·0	46,481	151,310	197,790	34·6

(iv.) V = 5,000 t = 25.

n.	C.	D.	P_1.	P_2.	P_3.	K.
1	17·63	587·4	439	443	881	0·5
2	17·72	587·4	877	895	1,772	1·0
5	17·98	587·2	2,192	2,304	4,496	2·4
10	18·42	587·6	4,380	4,840	9,220	3·7
20	19·29	584·5	8,727	10,655	19,382	9·1
50	21·79	569·8	21,270	34,892	56,162	19·5
100	25·38	525·4	39,220	102,681	141,901	30·9
150	28·06	469·9	52,620	210,480	263,100	37·5
200	29·94	415·4	62,013	361,430	423,440	41·5
250	31·24	467·0	68,481	556,550	625,030	43·9
300	32·13	325·8	72,970	795,990	868,960	45·4
350	32·77	291·4	76,140	1,079,700	1,155,800	46·5
400	33·23	262·7	78,440	1,407,600	1,486,000	47·2
450	33·57	238·6	80,140	1,779,500	1,859,700	47·8
500	33·83	218·2	81,426	2,195,500	2,276,900	48·2

In each case the power to be transmitted, P, has been taken as 87,700 watts, which, with motors of 85 per cent. efficiency, will give 100 brake h.p.

The curves (*see* pp. 500 and 501) and tables show what changes are produced in the different quantities tabulated—the most economical current density being employed in each case. I should mention that in the curves and tables are included P_1, P_2, P_3, and K where

P_1 = waste of energy in conductor.
P_2 = interest, depreciation, etc., on capital laid out in cable.
P_3 = $P_1 + P_2$.
K = percentage loss of volts in transmission of the power in each case.

You will notice that in cases of transmission of power over a considerable distance, P_1, the power wasted, bears a pretty high ratio to P, the power transmitted, so that the power of the generators must be considerably in excess of that actually required by the motors.

Now the value of U, and hence of t, depends to a certain extent upon the power of the generators $(P+P_1)$, and it is not difficult to see that this relation can be expressed by the equation

$$t=\sqrt{\frac{P+P_1}{A+B\,P_1}},$$ where A and B are constants depending on the conditions of the case under consideration. However, from these tables it is easy to judge approximately beforehand what P_1 will be in any given case, so that $P+P_1$ being known, t can be then accurately estimated, and C and D obtained as before.

To take an example, let us suppose that we want to transmit 100 brake h.p. from a waterfall to a mill at a distance of five miles. We will suppose that there is an effective head of 37ft., that the efficiency of the motors is 85 per cent., that the loss in the line is about 15 per cent., that the generators have an efficiency of 87 per cent., that there is a loss of 5 per cent. in belting, and that we take 2,000 volts as our working pressure.

The power to be transmitted to motors will be 87,700 watts, that developed by the generators 110,000 watts, and that given out by turbines 164 brake h.p.

For the water engines I shall suppose that we use 15in. Victor turbines, of which the cost, and also that of the accessories, etc., has been kindly furnished me by Mr. Nell, and for the dynamos (motors and generators) I shall take the costs of Victoria machines in this example.

For the case we are considering, then, I estimate the costs as under:

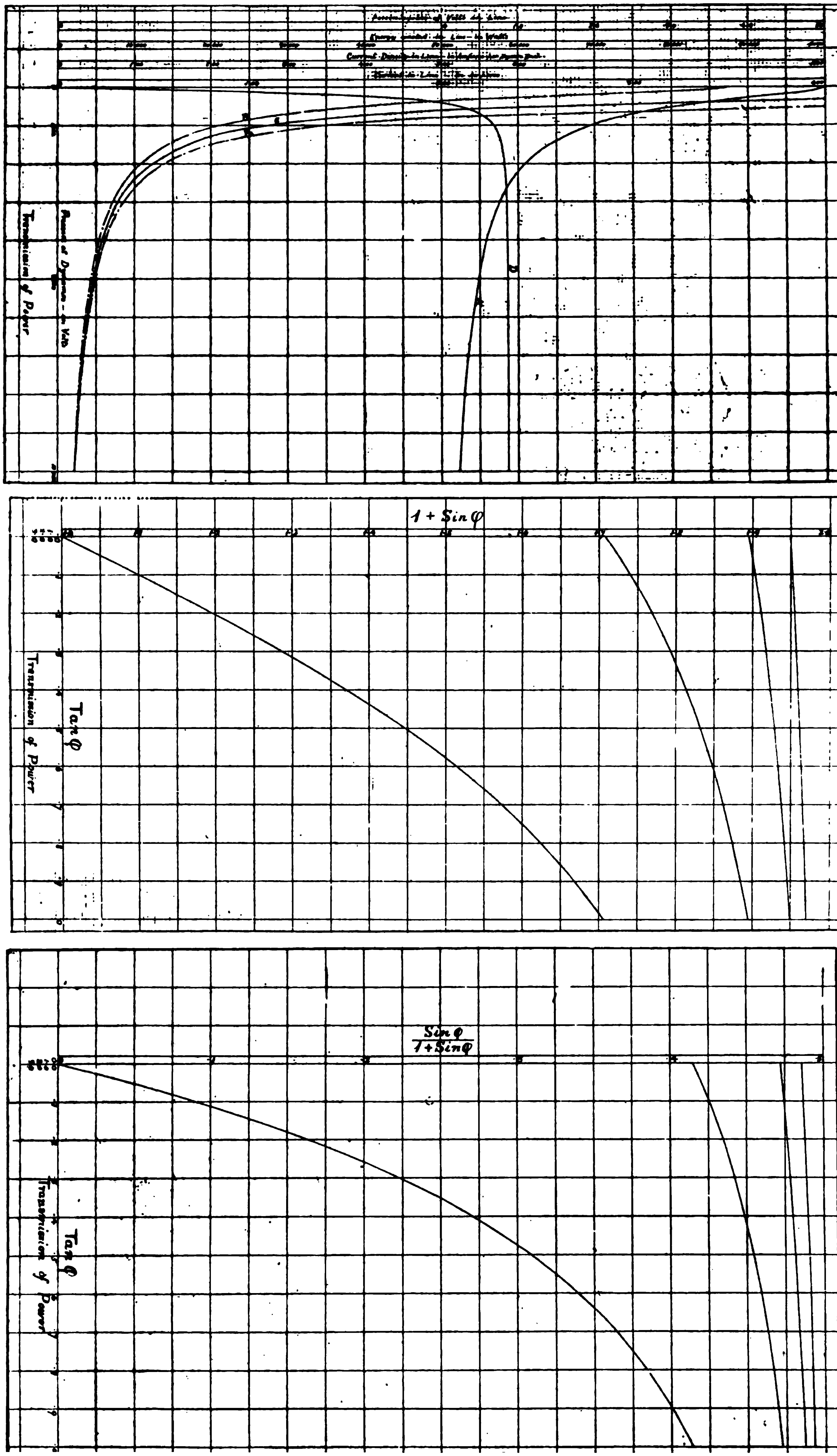
Machinery and line (including posts, insulators, etc., but no cable)	£2,500
Buildings, foundations, pipes, etc...........	870
Labour (including running of cable)	750
Sundries	180
Total	£4,300

Taking then

17½ per cent. on £2,500	£437	10	0
12½ „ „ £870	108	15	0
7½ „ „ £750	56	5	0
10 „ „ £180	18	0	0
Total..............................	£620	10	0

Cost of running machinery at both ends, and sundries (say) £150

(*Continued on page 505*).



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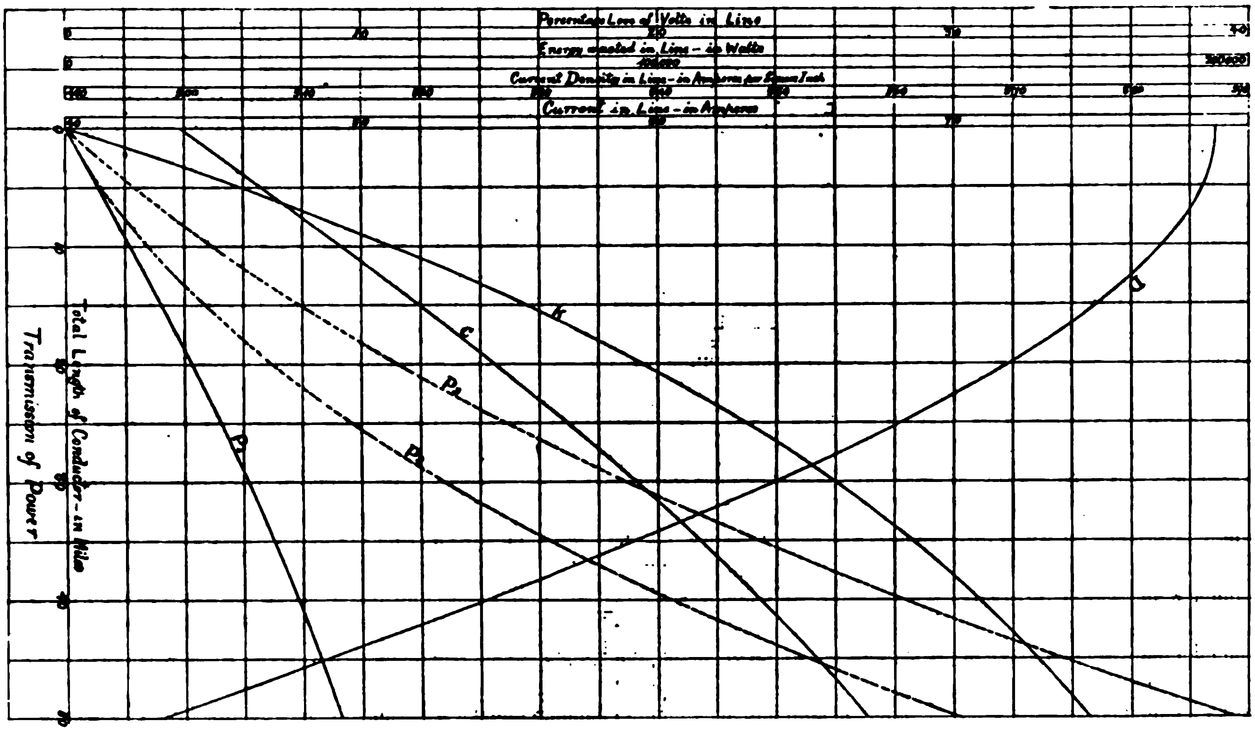

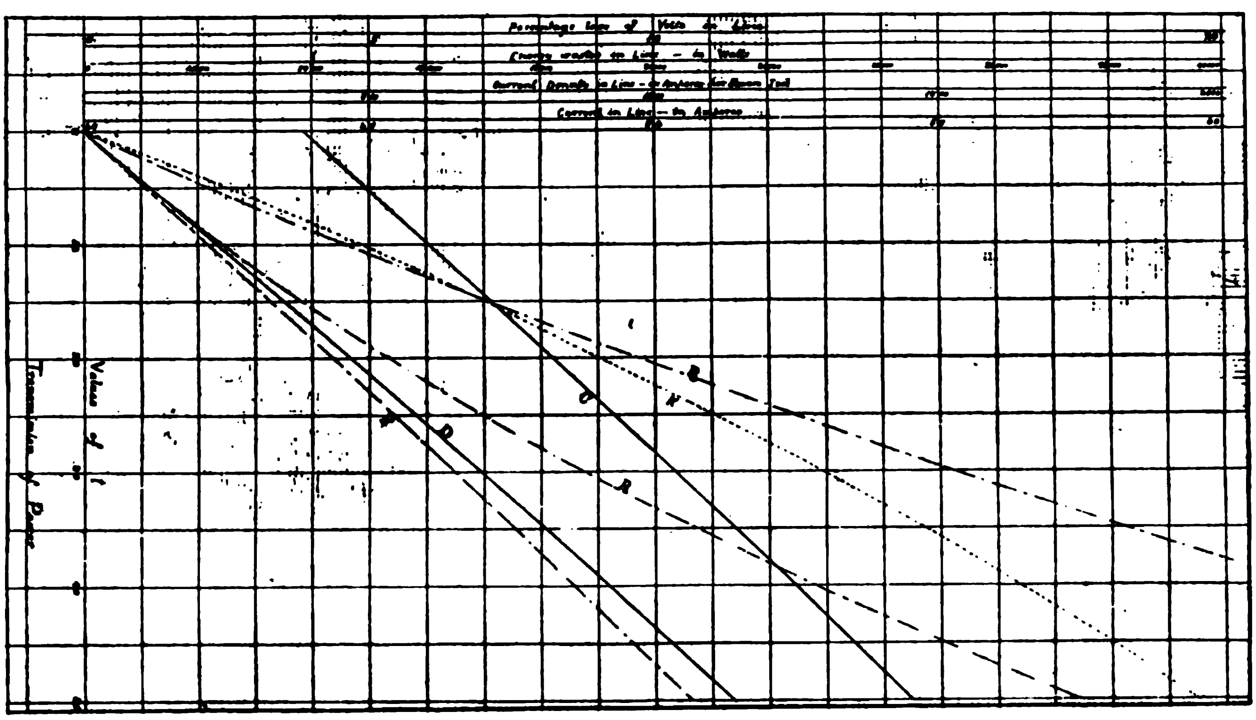

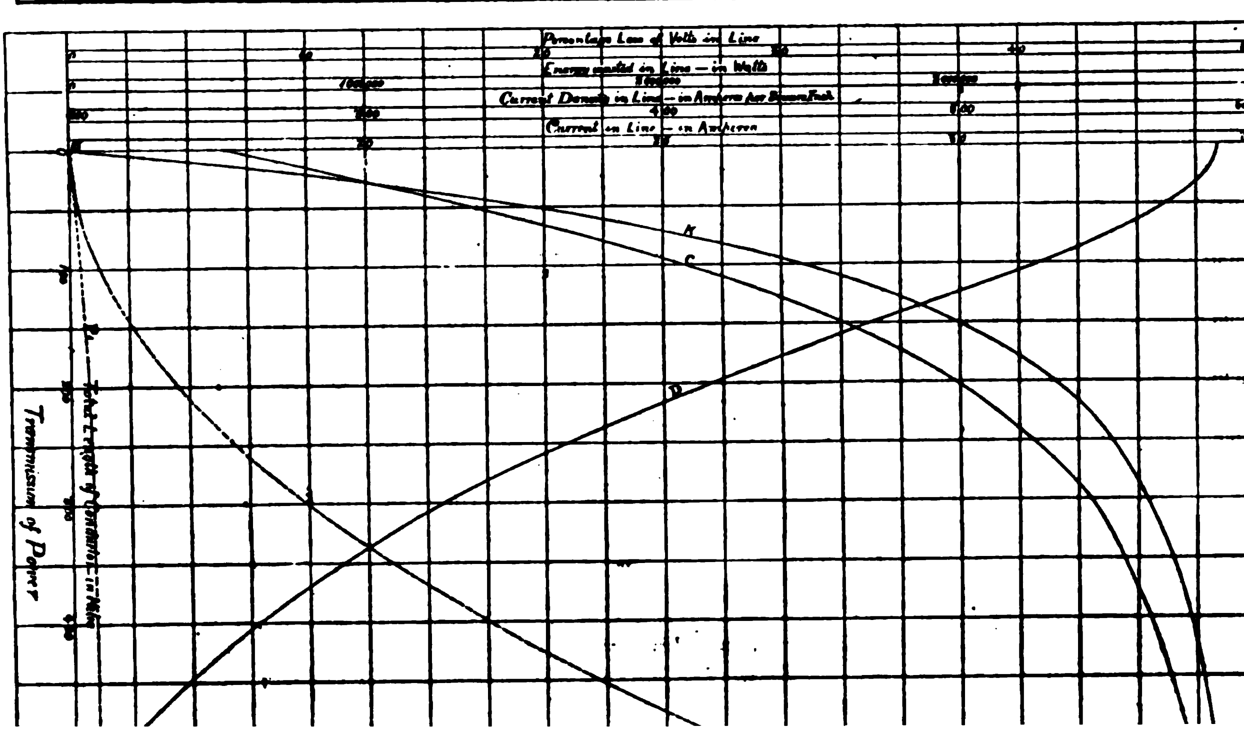

CURVES ACCOMPANYING MR. KILGOUR'S PAPER ON ECONOMY IN CONDUCTORS.

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ACCUMULATOR TRACTION.

The question of tramcar traction by accumulators has taken a fresh turn this week, and we think our readers will be thankful to learn how matters seem to stand upon this important point. The electrical world in England has been somewhat anxiously and cynically watching for developments in traction by accumulators, and sundry hints as to unknown depreciation of the battery plates and shakings of head as to the practical outcome of well-known experimental tracks have been all that has come before their notice. Last week an advertisement appeared in the usual papers with reference to the North Metropolitan Tramways, notice being given of a proposed amendment to section 4 of that company's Act of 1890 to the following effect:

"That application is intended to be made to Parliament in the ensuing session, by the North Metropolitan Tramway Company, for an Act to alter and amend or to repeal the provisions contained in section 4 of the North Metropolitan Tramways Act, 1890, relating to the consents of the local authorities referred to in that section, and to make other provisions with reference thereto, and so far as necessary to alter or amend or repeal the provision of any other Act relating to the company, and to vary and extinguish any rights or privileges which would or might interfere with the objects aforesaid."

This action upon the part of the North Metropolitan Company is both an indication of their determination not to be over-ridden by moribund vestries, and at the same time a very telling commentary upon the criticisms which insist that accumulators for traction cannot pay.

It may be remembered that the North Metropolitan Company having granted the use of one of their lines to be equipped at Barking-road, experiments at first, and now for some time practical running, have been carried on upon this road with the storage cars of the General Electric Traction Company. Two causes, having no relation to each other, have prevented the more extended and permanent use of these accumulator cars on the tramway company's roads. The first of these, the question of cost of maintenance and depreciation of the cells, we will return to presently. The second has been the continued refusal of the West Ham Local Board to accord anything like a reasonable permission to run the electric cars. All endeavours up to the present time of both electric company and tramway company themselves have resulted in the refusal of the West Ham authorities to grant a longer permission than one year, with the condition of enforced removal after only 24 hours' notice. Such a condition as this is absolutely prohibitive for the North Metropolitan or any other company to put down plant on an extensive scale—with the fear of notice of removal at 24 hours' notice hanging over them. They have first applied to the London County Council to learn if this body would grant a seven years' permission for running electric cars, and we learn from the proceedings of the London County Council that this permission has now been granted upon condition of

putting the permanent way in thorough repair and of taking such precautions for the public safety as the Council shall think fit. The North Metropolitan, then, finding it impossible to induce the West Ham authorities to alter their terms, have taken steps to introduce the afore-mentioned Bill into Parliament in the present session, with a view, it may be supposed, of compelling them to give this permission, if the notice itself is not sufficient to force their hands.

The very fact that a large company like the North Metropolitan intend to fight the matter for themselves in Parliament, is itself striking evidence as to whether they do or do not regard electric traction as a desirable thing. It is not to be supposed that they would go so far, and would consider the investment of capital necessitated by the necessary plant and stock which it means, without a good assurance of the profitableness of the undertaking.

We are in a position to state a little more clearly than has hitherto been done what are the arrangements concluded, or likely to be concluded, in this direction. Electrical engineers have been looking for the publication of the balance-sheet of the Barking-road route to enable them to judge of the advisability of accumulator traction. It is doubtful, and more than doubtful, if this balance-sheet will ever be published, at any rate for the period up to the present. The experience which has been gained has been avowedly an experimental experience, and the actual total cost of management, alteration, and depreciation, whether it comes out at 4½d., or even double, if it allows future contracts to be regulated on a paying basis, will, in either case, be lightly bought—and all the while money has certainly been earned. The expenses upon the line have been reduced continually until they are now within the limits from which the expenses upon a considerable scale can be calculated with accuracy. Certain important improvements in the type of traction cell have been introduced, which have had the effect of still further reducing the depreciation on traction cells to within reasonable limits, of which, perhaps, it may be sufficient to say that the prolonged tests show that the combined life of the positive and negative plates equals two years. An important feature in the case is that the makers of the cells, the Electric Construction Corporation, have arranged to undertake the maintenance of the cells, in fair usage, for a definite sum or percentage, a matter which allows the actual total cost—the other factors being already sufficiently closely known—to be now calculated with accuracy. The actual cost of depreciation for a plant of 50 cars we are assured thus comes out at about 1d. per car mile—that is, for maintenance of the cells alone, be it understood.

The other important point, and one which arises out of and takes its possibilities from this action of the makers of the cells, is that of the proposed arrangement between the traction company and tramway company. The North Metropolitan Company, who received the Glasgow Corporation some little time ago and allowed them the fullest facilities of inspection and enquiry, intimated to these latter that they intended to give no more contracts for haulage, but that they contemplated installing their own plant, and would contract for the *maintenance in good order of the electric plant.* This determination is worthy the consideration of both tramway companies and electrical engineers, and solves the difficulties both of management of men, stock, and capital, that would be too likely to interfere in an absolute contract for haulage at so much per car mile—when the electrical men and the tram men would be under separate authority, and other difficulties would also be likely to arise. With the proposed arrangement the electrical company would put down the plant at the expense of the tramway company, and would thereafter contract—according to the length of line, number of cars, and other matters—for the *maintenance* of the electrical part of the installation, and at so much per car mile. The necessary trials and figures are so far settled with both the makers and the traction company, that these latter are able and willing to enter, at the present time, into contracts for 10, 100, or 1,000 storage cars, and to maintain the electrical part in order at a fixed charge according to circumstances per car mile. We are sure all will be glad to hear of arrangements seemingly so promising for the progress of electric traction in England.

PECCAVIMUS.

Yes, and with our eyes wide open too. In large paper mills and in other manufactories where bleaching operations on a large scale are required electricity must, in the future, play an important *rôle.* Our well-known contributor, Mr. Watt, writing on the subject in our issue of October 31st, as was natural, referred to his brother's work in this direction, and maintained that his brother was the pioneer inventor of the method. Mr. Andreoli controverted this statement, and now Mr. Watt returns to the fray. From our point of view little or no good can arise from an extended controversy, which will necessarily lead to crimination and recrimination, and will show how very differently men interpret the same sentences. Our aim in the first place was to once more indicate a direction which might advantageously be exploited by dynamo builders, for dynamos must be used when the process is adopted, as must engines, besides other electrical accessories. The discussion is practically to determine the exact claim to priority of Mr. C. Watt, a claim, which if admitted freely and ungrudgingly, has no influence upon business now, inasmuch as this patent has long since lapsed. We think therefore that it will

be better to terminate the discussion with the reply of Mr. Watt. Those interested can easily turn up the passages referred to by Messrs. Andreoli and Watt, and interpret for themselves.

CORRESPONDENCE.

ORIGIN OF ELECTROLYTIC BLEACHING.

To the Editor of the Electrical Engineer.

Sir,—Mr. Andreoli; in a letter which appeared in your issue of the 21st ult., and to which I should have replied earlier had I not been unwell, has made an attempt, or several attempts, to prove that Mr. Charles Watt's patent, 1851, for the electrolytic production of hypochlorites of sodium, etc., was neither original nor of any practical value; and in order to support the first of these assertions, he "exhumes," to use his own phrase, several old processes having totally different objects and producing effects with which hypochlorites have no concern, or in which they play no part whatever. As an example of Mr. Andreoli's ingenuity, I have only to show how "cleverly," to use his own phrase also, he has twisted a suggestion of the late Prof. Brande ("Manual of Chemistry," footnote p. 222) into an application of electrolytic hypochlorite of sodium to the art of calico printing. Now what Brande really says in the footnote referred to is this: "In the year 1820 I suggested the possibility of applying these electro-chemical effects to the art of calico printing, and showed that by bringing a small disc or figure of platinum, rendered electro-positive, upon a piece of coloured calico imbued with a solution of salt, and stretched over an electro-negative surface, white spots or patterns might be produced *in consequence of the action of the evolved chlorial*, and that *by reversing the electric state of the pattern the alkali evolved would produce variously coloured patterns* upon grounds properly prepared for the purpose. A patent has been taken out by Mr. Bagg for a similar application of electricity, in which he proposes to produce various colours by the application of patterns formed of plates of various metals and alloys, acting upon different saline solutions." Now it will be noticed (1) that Mr. Brande makes no reference whatever to "electrolytic hypochlorites," and (2) that such hypochlorites could not be produced in the way proposed by him for producing the white and coloured patterns referred to, since the evolved elements, chlorine and sodium, must necessarily be kept apart to effect the object in view. The same observations also dispose of Mr. Bagg's connection with "electrolytic hypochlorites."

We are also told, as further evidence of the unsoundness of Mr. C. Watt's patent, that "in 1840 Th. Léikauf made experiments on bleaching by electricity, but they hardly deserved to be mentioned" (!) We are further reminded by Mr. Andreoli that Gmelin's "Handbook of Chemistry," 1848, it is stated that "a solution of common salt gives Cl at the + and H gas and soda at the − pole." That these well-known electro-chemical facts would receive recognition in handbooks of chemistry goes without saying, but a patent for a well-defined process for the practical application of the principle involved would not be vitiated by the mere publication of a scientific fact.

In trying to pull Mr. C. Watt's patent to pieces to furnish himself with argument against it, I find that Mr. Andreoli—as he did in the extract from Brande referred to—has entirely, and I think unfairly, misrepresented that portion of Mr. C. Watt's process which relates to the production of hypochlorites. Mr. Andreoli says "Charles Watt's electro-bleaching consists in decomposing a concentrated solution of chloride of sodium by means of the electric current, such solution being kept hot by means of vessels divided into compartments separated from each other by porous partitions." Now the *third part* of Mr. C. Watt's specification "consists of a mode of converting chlorides of potassium and sodium, and of the metals of the alkaline earths, into hypochlorites and chlorates." No mention whatever is made of "vessels divided into compartments separated from each other by porous partitions," an arrangement which would be, as Mr. Andreoli must have known when he quoted this part of Mr. C. Watt's specification, an absolute absurdity. Neither is there any arrangement for partitions depicted in the drawing which accompanies the specification. It is also erroneous to state that the solution of chloride of sodium is "kept hot," since the words actually used are, "*a warm solution*, nearly saturated"—not "concentrated," as Mr. Andreoli puts it. Again, Mr C. Watt says: "If I desire to produce a hypochlorite of the alkali or earth, *I merely keep the solution warm*."

In reference to my brother's specification prescribing a "nearly saturated" solution of chloride of sodium—which Mr. Andreoli has tried to serve his purpose by calling it a "concentrated" solution—Mr. Andreoli says, at the end of the first column of his letter, "A concentrated solution means a considerable expenditure and an enormous loss of chloride of sodium," whereas, in the third column of his letter, in which he quotes a formula given by some French experimentalist who "dissolves chloride of sodium in water in the proportion of 50 grammes of sea salt for every litre of water," Mr. Andreoli says, "But instead of 50 grammes being dissolved per litre, 100, 200, *or enough to saturate the solution* can be used." It is really impossible to deal with such weather-cock statements, so I will here take my leave of Mr. Andreoli, for I have no desire to continue a controversy in which such erroneous statements usurp the place of legitimate argument.

Respecting my brother's patent, however, I may repeat that it has evidently formed the basis of all, or nearly all, subsequent patents having for their object the carrying out of the various processes therein described. As a patent it is one of the most comprehensive I have seen and was devised by one of the most practical chemists of his day, Mr. C. Watt having had, even so far back as 1851, great experience with the alkali trade. As a final observation I may state that Mr. C. Watt's specification has been at least once or twice "out of print," a sure guarantee that it had been well sought after by intending "inventors."—I am, etc.

Alexander Watt.

BARROW-IN-FURNESS.

To the Editor of The Electrical Engineer.

Sir,—Your correspondent "Electric Light," in the *Electrical Engineer* of the 28th ult., raises the question as to cost of electric lighting to consumers, and questions the figures quoted by the town clerk in his circular. The statement that the cost of equal light will be from 20 to 100 per cent. greater than that of gas is well within the mark—indeed, three to four times the cost of gas is often found to more nearly represent the outlay incurred. It is an open secret nowadays that the cost of producing electrical energy runs somewhat about the equivalent of gas at 4s. to 4s. 3d. per 1,000 cubic feet.

In the mention of the lamp life of 900 hours, Mr. Preston is hardly quoting the results of experience, as it has been found on English central stations circuits that 500 to 600 hours is the most to be reckoned upon where anything like an attempt is made to incandesce the lamps to give 16 c.p. at about 3·5 watts per candle-power.

The point not often raised in favour of the electric illuminant, but one which more than any other tends to reduce the charges made on the consumer, is the facility for suddenly lighting up any premises at any hour of the night, thus economising over gas where every burner consumes two to three cubic feet per hour. This effect has, however, been unfelt, because so few stations as yet give 24 hours' supply.—Yours, etc.,

Charles H. Yeaman.

Electric Department, City Engineer's Office, Liverpool, W., Dec. 2.

Swiss Telegraphs.—Dr. Rothen, hitherto Director of Swiss Telegraphs, has been appointed to the vacant post of Director of International Telegraphs, in the place of the late M. Frei.

NOTES ON ECONOMY IN CONDUCTORS.

(*Continued from page 499*).

The total annual expenditure in the production of 110,000 watts is therefore £770 for 2,808 hours (54 hours per week) per annum, or $U = 0{\cdot}6$d.; hence $t = 26{\cdot}7$ very approximately if we assume use of bare wire and take copper at 9½d. per pound, and interest, depreciation, etc., on cable at 15 per cent.

Then, since

$$t = 26{\cdot}7$$
$$V = 2{,}000$$
$$n = 10,$$
$$\tan\phi = 0{\cdot}1335$$

and

$$C = 49{\cdot}6 \text{ amperes}$$
$$D = 547 \text{ amperes per square inch.}$$

The necessary conductor would weigh about 10,120lb. per mile, and cost £390 per mile. In it the loss of power would be about 12 per cent., so that we rather over-estimated it when taking this at 15 per cent.

The following general notes on conductors may be of some use:

Of cables of the same class of insulation, and the same insulation resistance per mile, and the same cross-sectional area, a single wire is the cheapest, and the fewer the number of wires in a strand, the cheaper is the cable. For example, take Silvertown class S, in which the single wires are about 18 per cent. cheaper than the stranded cables of equal cross-sectional area.

A concentric cable is generally, as you would expect, considerably dearer than two separate conductors with the same class of insulation and the same insulation resistance per mile between the going and return conductor.

A cylinder of copper of one square inch area and one mile long weighs 20,400lb., or 9·1 tons very approximately, and it has a resistance of 0·0425 ω per mile at 60deg. F.

Such a cylinder 100 yards long weighs 1,160lb., or 0·52 tons, and has a resistance of 0·0024 ω per mile approximately.

These values apply equally to stranded cables with a high degree of approximation.

With stranded cables the effective area of cross-section and the weight per mile are about 2½ per cent. to 3 per cent. greater, and the resistance per mile is 2½ per cent. to 3 per cent. less than that of a cable composed of the same number of parallel wires.

COUPLING ALTERNATORS IN SERIES.*

BY PAUL BOUCHEROT.

The fact is well known that if two alternate-current machines are connected terminal to terminal the electromotive forces tend to become opposed to each other.

The explanation of this phenomenon has been given by

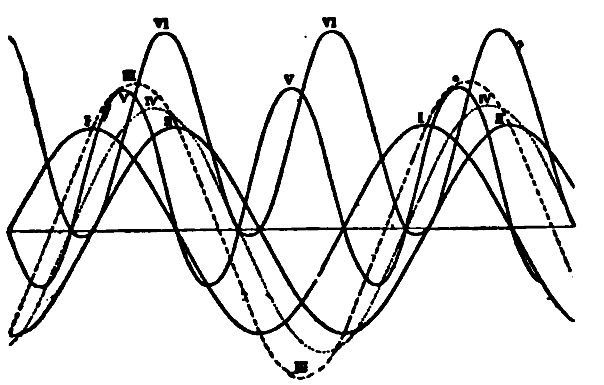


FIG. 1.—Particulars of Two Alternators at the Moment of Connection, Terminal to Terminal.

I. E.M.F. of forward dynamo. II. E.M.F. of backward dynamo. III. Total E.M.F. IV. Current resulting from total E.M.F. V. Energy produced by forward dynamo. VI. Energy produced by backward dynamo.

Dr. John Hopkinson. At the moment of coupling there is always a difference of phase, however small it may be, between the E.M.F.'s of the two dynamos; from this results (see Fig. 1) a total E.M.F. whose maximum values are, in time, at equal distance from the maximum values of each E.M.F.; in other words, a total E.M.F. which has, as difference of phase between itself and each of the E.M.F.'s, half the difference of phase existing between themselves. The strength of current which results from this total E.M.F. lags somewhat behind, owing to the self-induction, and its curve approaches most nearly to that of the E.M.F. of the backward dynamo than to that of the other.

It results from this that the energy produced by this dynamo is the larger, which again contributes towards increasing its lagging until the moment when the two E.M.F.'s, separating more and more, at last become in actual opposition. In a word, the opposition of the E.M.F.'s is a stable equilibrium, their superposition is an unstable equilibrium.

It is, therefore, only by reason of the gradual dwindling of the current strength behind, a dwindling produced by the self-induction, that this coupling in opposition takes place automatically. It is easy to conceive that, if instead of a dwindling behind, there were to be a dwindling in front—and a condenser placed in circuit will give this result (*L'Electricien*, Nov. 15, 1890)—then the E.M.F.'s would group themselves in series; the curve of current strength approaching more nearly to the curve of E.M.F. of the forward dynamo than to that of the other, the energy of this dynamo will be the greater, which will tend to retard it, until that moment when the E.M.F.'s approaching each other more and more at last are superposed.

The superposition of the E.M.F.'s will then be a stable equilibrium, and their opposition an unstable equilibrium.

To group alternators in series, then, all that is necessary to do is to introduce in their circuit a capacity *weak* enough to destroy the self-induction, and at the same time to reduce sufficiently the current strength, but *strong* enough not to have too large a C E.M.F., and not to diminish too much the available difference of potential.

As with the self-induction, so with the current strength. The greater the reduction (that is, the smaller C becomes) the better the coupling will take place, but also the more the available difference of potential in full work will be diminished.

But there is no illusion to be made about this expedient, since it completely forbids the use of such apparatus which, like transformers, only work usefully by reason of their self-induction, as it is necessary to destroy this.

It is, therefore, necessary to diminish first the current strength in the machines without changing the respective position of the phases in the distributive circuit. This will be brought about by placing the condenser as shunt to the terminals of the distributing circuit (see Fig. 2). But the necessary capacity is no longer determined by the relation $\omega^2 L C < 1$. This is not only a function of the self-induction of the distributing circuit, it is also a function of its resistance.

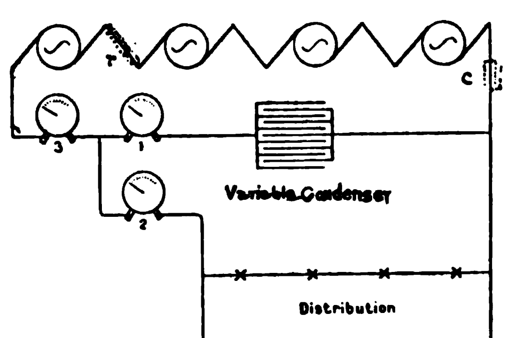


FIG. 2.—Coupling Alternators in Series.

It is sufficient that the electrodynamometer 1 indicates as much as the electrodynamometer 2. The electrodynamometer 3 then gives an approximate idea of the amount of self-induction in the distributing circuit. The dotted condenser shows the position of the fixed condenser mentioned afterwards.

The current in the distributing circuit is

$$I_t = E_{max} \frac{R \sin \omega t - \omega L \cos \omega t}{R^2 + \omega^2 L^2}$$

* Translated from *L'Electricien*, November 29, 1890.

and that in the condenser

$$I'_t = E_{max}\, \omega\, C \cos \omega t$$

The total intensity is therefore :

$$E_{max} \left(\frac{R \sin \omega t}{R^2 + \omega^2 L^2} + \frac{(R^2 + \omega^2 L^2)\, \omega C - \omega L}{R^2 + \omega^2 L^2} \cos \omega t \right)$$

and for this current strength to be in advance, the coefficient of $\cos \omega t$ must be positive—that is, that we must have :

$$C > \frac{L}{R^2 + \omega^2 L^2}$$

Now, this condition can be realised in a simple manner, without knowing either the self-induction or the resistance of the distributing circuit :

It is sufficient, by varying the capacity, to maintain the available current strength in the condenser equal to the available current strength in the distributing circuit.

In fact, in the condenser

$$I'_{av} = E_{av}\, \omega C,$$

and in the distributing circuit

$$I_{av} = \frac{E_{av}}{\sqrt{R^2 + \omega^2 L^2}}$$

By making these equal we get

$$\omega C = \frac{1}{\sqrt{R^2 + \omega^2 L^2}} = \frac{\sqrt{R^2 + \omega^2 L^2}}{R^2 + \omega^2 L^2};$$

and, as $\sqrt{R^2 + \omega^2 L^2}$ is always greater than ωL, we get

$$\omega C > \frac{\omega L}{R^2 + \omega^2 L^2}.$$

The solution is, therefore, simple. It is not, moreover, too costly. Suppose that it is desired to group in series five machines of 500 volts and 25 amperes in order to obtain a pressure of 2,500 volts. A variable condenser of a maximum capacity of 20 microfarads will suffice for all the requirements of working. The microfarad condenser of commerce to resist a pressure of 2,500 volts will cost about 20s. This is not an excessive expense. It might be considered sufficient to put a condenser of the constant capacity of 20 microfarads upon the machines, but the strength of current would always be from 20 to 25 amperes, whatever the expenditure in the distributing circuit, and this would be less advantageous by reason of the $r\, I^2$ lost in the armature. For the rest, it is a slight inconvenience of this proceeding to make the $r\, I^2$ lost in the armature larger than what it would be without condenser. The available strength of current in the armature is, in fact, equal to the available strength of current in the circuit multiplied by

$$\sqrt{2 - \frac{2\, \omega L}{\sqrt{R^2 + \omega^2 L^2}}}$$

and unless R is nil it is always larger than this latter. The largest ratio there can be between the two is $\sqrt{2}$ for $L = 0$. The loss of energy in the armatures can therefore attain to twice the value it would have without condenser.

If it is not desired to allow so great a loss and to rely upon a smaller reduction, it would be necessary to know the reduction, ϕ, in the backward direction of the distributing circuit, and to make the available current strength in the condenser rather larger than the product of the available current strength of distribution by $\sin \phi$.

But in these calculations the dynamos to be coupled are supposed to be without self-induction, which is the case only in theory. In practice, the dynamos always having some self-induction, this must be kept in view. Two cases, then, have to be considered. The network of distributing mains may be variable in resistance and self-induction, or it may be constant. In the first case, it is always preferable to bring all to the theoretical case in which there is no self-induction, and this by destroying the effects of this self-induction by a constant condenser, c, such that $\omega^2\, l\, c = 1$, placed in the circuit of the dynamos (see dotted lines Fig. 2). Not having at each instant any idea of R and of L of the distributing circuit, there can be no simple process for reducing the forward current strength with the sole aid of the condenser, C, placed in shunt upon the distributing circuit ; by the addition of the condenser c, all that is necessary to maintain the series coupling is to vary C at the same time that R and L vary in the distributing circuit, so as to have the available current strength in the condenser always equal to the available current strength of the distributing circuit.

The addition of this condenser, c, is not very costly, and, besides, its cost would be regained by the added useful energy of the machines.

When the values of the resistance and of the self-induction are known, one single condenser in shunt on the circuit may be enough. A long calculation, which it is not necessary to reproduce here, shows the condition found, in order that the current strength shall be reduced in advance, to be

$$\frac{R^2\, \omega\, C\, (1 - \omega^2\, l\, C)}{\omega L + \omega\, l\, (1 - \omega^2 L C)} + \omega^2 L C > 1,$$

from which the extreme limits of C may be found.

In fine, if the values of L and of R, although variable, always satisfy the condition $R > \omega L > 2\, \omega\, l$, or even to this other condition, more complicated but less exacting, $R^2 (2\, \omega L - \omega\, l) > \omega^2 L^2 (\omega L + \omega\, l)$, it is sufficient to vary the condenser in such a way that the available current strength in its circuit shall be always equal to the total available current strength which flows in the coils, which leads to the result of making $\omega^2 L C = \frac{1}{2}$.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

LECTURE III.

(*Continued from page 486.*)

SPECIFICATIONS OF ELECTROMAGNETS.

One frequently comes across specifications for construction which prescribe that an electromagnet shall be wound so that its coil shall have a certain resistance. This is an absurdity. Resistance does not help to magnetise the core. A better way of prescribing the winding is to name the ampere-turns and the temperature limit of heating. Another is to prescribe the number of watts of energy which the magnet is to take. Indeed, it would be well if electricians could agree upon some sort of figure of merit by which to compare electromagnets, which should take into account the magnetic output—*i.e.*, the product of magnetic flux into magneto-motive force ; the consumption of energy in watts, the temperature rise, and the like.

AMATEUR RULE ABOUT RESISTANCE OF ELECTROMAGNET AND BATTERY.

In dealing with this question of winding copper on a magnet core, I cannot desist from referring to that rule which is so often given, which I often wish might disappear from our text-books : the rule which tells you in effect that you are to waste 50 per cent. of the energy you employ. I refer to the rule which states that you will get the maximum effect out of an electromagnet if you so wind it that the resistance is equal to the resistance of the battery you employ ; or that if you have a magnet of a given resistance you ought to employ a battery of the same resistance. What is the meaning of this rule ? It is a rule which is absolutely meaningless, unless in the first case the volume of the coil is prescribed once for all, and you cannot alter it, or unless, once for all, the number of battery elements that you can have is prescribed. If you have to deal with a fixed number of battery elements, and you have to get out of them the biggest effect in your external circuit, and you cannot beg, buy, or borrow any more cells, it is perfectly true that, for steady currents, you ought to group them so that their internal resistance is equal to the external resistance that they have to work through ; and then, as a matter of fact, half the energy of the battery will be wasted, but the output will be a maximum. Now that is a very nice rule indeed for amateurs, because an amateur generally starts with the notion that he does not want to economise in his rate of working ; it does not matter whether the battery is working away furiously, heating itself, and wasting a lot of power ; all he wants is to have the biggest possible effect for a little time out of the fewest cells. It is purely an amateur's rule, therefore, about equating the resistance inside to the resistance outside. But it is absolutely fallacious to set up any such rule for serious working ; and not only fallacious, but absolutely untrue if you are going to deal with currents that are going to be turned off and on quickly. For any apparatus like an electric bell, or rapid telegraph, or induction coil, or any of those things where the current is going to vary up and down rapidly, it is a false rule, as we shall see presently. What is the real point of view from which one ought to start ? I am often asked questions by, shall I say, amateurs, as well as by those who are not amateurs, about prescribing the battery for a given electromagnet, or prescribing an electromagnet for a given battery. Again, I am often told of cases of failure in which a very little common-sense rightly directed might have made a success. What one ought to think about in every case is not the battery, not the electromagnet,

* Cantor lectures, delivered before the Society of Arts.

but the line. If you have a line, then you must have a battery and electromagnet to correspond. If the line is short and thick, a few feet of good copper wire, you should have a short thick battery (a few big cells, or one big cell), and a short thick coil on your electromagnet. If you have a long thin line, miles of it, say, you want a long thin battery (small cells, and a long row of them) and a long thin coil. That is, then, our rule, for a short thick line, a short thick battery, and a short thick coil; for a long thin line, a long thin battery; and electromagnet coils to match. You smile; but it is a really good rule that I am giving you; vastly better than the worn-out amateur rule.

But, after all, my rule does not settle the whole question, because there is something more than the whole resistance of the circuit to be taken into account. Whenever you come to rapidly-acting apparatus you have to think of the fact that the current, while varying, is governed not so much by the resistance as by the inertia of the circuit—its electromagnetic inertia. As this is a matter which will claim our especial attention hereafter, I will leave battery rules for the present, and proceed with the question of design.

Forms of Electromagnets.

This at once leads us to consider the classification of forms of magnets. I do not pretend to have found a complete classification. There is a very singular book, written by Mons. Nicklès, in which he classifies under 37 different heads all conceivable kinds of magnets, bidromic, tridromic, monocnemic, multidromic, and I do not know how many more; but the classification is both unmeaning and unmanageable. For my present purpose I will simply pick out those which come under three or four heads, and deal separately with others that do not quite fit under any of the four categories.

Bar Electromagnets.—In the first place there are those which have a straight core, of which there are several specimens on the table here.

Horseshoe Electromagnets.—Then there are the horseshoes, of which some are of one piece bent, and others are of the more frequent shape, made of three pieces.

Iron-clad Electromagnets.—Then from the horseshoes I go to those magnets in which the return circuit of the iron comes back outside the coil either from one end or the other, or from both ends, sometimes in the form of an external tube or jacket, sometimes merely with a parallel return yoke, or two parallel return yokes. All such magnets I propose to call—following the fashion that has been adopted for dynamos—iron-clad electromagnets. One of them, the jacketed electromagnet, is shown in Fig. 12, p. 317, and there are others not so well known. There is one used by Mr. Cromwell Varley, in which a straight magnet is placed between a couple of iron caps, which fit over the ends, and virtually bring the poles down close together; the circular rim of one cap being the north pole, and that of the other cap being the south pole, the two rims being close together. That plan, of course, produces a great tendency to leak across from one rim to the other all round. The advantages, as well as the disadvantages, of the jacketed magnet I alluded to in my last lecture, when I pointed out to you that for all action at a distance it is far better not to have an iron-clad return path, whereas for action in contact the iron-clad magnet was distinctly a very good form. In one form of iron-clad magnet the end of the straight central core is fixed to the middle of a bar of iron, the ends of which are bent up and brought flush with the top of the bobbin, making thus a tripolar magnet, with one pole between the other two. The armature in this form is a bar which lies right across the three poles. There is an example of this excellent kind of electromagnet applied in one of the forms of electric bell indicator made by Messrs. Gent, of Leicester.

Fig. 50.—Club-footed Electromagnet.

Then besides these three main classes—the straight bar, the horseshoe, and the iron-clad—there is another form which is so useful, and so commonly employed in certain work that it deserves to have a name of its own. It is that called by Count du Moncel the *aimant boiteux*, or club-footed magnet, Fig. 50. It is a horseshoe, in fact, with a coil upon one pole and no coil upon the other. The advantage of that construction is simply, I suppose, that you will save labour—you will only have to wind the wire on one pole instead of two. Whether that is an improvement in any other sense is a question for experiment to determine; but on which theory perhaps might now be able to say something. Count Du Moncel, who made many experiments on this form of magnet, ascertained that there was for an equal weight of copper a slight falling off in power with the club-footed magnet. Indeed, one might almost predict for a given weight of copper, if you wound all in one coil only, you will not make as many turns as if you wound it in two; the outer turns on the coil being so much larger than the average turn when wound in two coils. Consequently, the number of ampere-turns with a given weight of copper would be rather smaller, and you would require more current to bring the magnetising power up to the same value as with the two coils. At the same time the one coil may be produced a little more cheaply than the two; and, indeed, such electromagnets are really quite common, being largely used, for the sake of cheapness and compactness, in indicators of electric bells.

Du Moncel tried various experiments about this form to find whether it acted better when the armature was pivoted over one pole or over the other, and found it worked best when the armature was actually hinged on to that pole which comes up through the coil. He made two experiments, trying coils on one or other limb, the armature being in each case set at an equal distance. In one experiment he found the pull was 35 grammes, with an armature hinged on to the idle pole, and 40 grammes when it was hinged on to the pole which carried the coil.

Another form of electromagnet having but one coil is used in the electric bells of church bell pattern, of which Mr. H. Jensen is the designer. In Jensen's electromagnet a straight cylindrical core receives the bobbin for the coil, and after this has been pushed into its place two ovate pole-pieces are screwed upon its ends, serving thus to bring the magnetic circuit across the ends of the bobbin, and forming a magnetic gap along the side of the bobbin. The armature is a rectangular strip of soft iron, about the same length as the core, and is attracted at one end by one pole-piece, and at the other end by the other.

Effect of Size of Coils.

Seeing that the magnetising power which a coil exerts on the magnetic circuit which it surrounds is simply proportional to the ampere-turns, it follows that those turns which lie on the outside layers of the coil, though they are further away from the iron core, possess precisely equal magnetising power. This is strictly true for all closed magnetic circuits; but in those open magnetic circuits where leakage occurs it is only true for those coils which encircle the leakage lines also. For example, in a short bar electromagnet of the wide turns on the outer layer, those which encircle the middle part of the bar do enclose all the magnetic lines, and are just as operative as the smaller turns that underlie them, whilst those wide turns which encircle the end portions of the bar are not so efficient as some of the magnetic lines leak back past these coils.

Effect of Position of Coils.

Among the other researches which Du Moncel made with respect to electromagnets was one on the best position for placing the coil upon the iron core. This is a matter that other experimenters have examined. In Dub's book "Electromagnetismus," to which I have several times referred, you will also find many experiments on the best position of a coil; but it is, perhaps, sufficient to narrate a single example. Du Moncel had four pairs of bobbins made of exactly the same length, and with 50 metres of wire on each, one pair was 16 centimetres long, another pair eight centimetres, or half the length, with not quite so many turns, because, of course, the diameter of the outer turns was larger, one four centimetres in length, and another two centimetres. These were tried both with bar magnets and horseshoes. It will suffice, perhaps, to give the result of the horseshoe. The horseshoe was made long enough—16 centimetres only, a little over 6in. long—to carry the longest coil. Now, when the compact coils two centimetres long were used, the pull on the armature at a distance away of two millimetres (it was always the same, of course, in the experiments) was 40 grammes. Using the same weight of wire, but distributed on the coils twice as long, the pull was 55 grammes. Using the coils eight centimetres long, it was 75 grammes; and using the coils 16 centimetres long, covering the length of each limb, the pull was 85, clearly showing that, where you have a given length of iron, the best way of winding a magnet to make it pull with its greatest pull is not to heap the coil up against the poles, but to wind it uniformly, for this mode of winding will give you more turns—therefore more ampere-turns, therefore more magnetisation. An exception might, however, occur in some case where there is a large percentage of leakage. With club-footed magnets results of the same kind are obtained. It was found in every case that it was well to distribute the coil as much as possible along the length of the limb. All these experiments were made with a steady current. It does not follow, however, because winding the wire over the whole length of core is best for steady currents that it is the best winding in the case of a rapidly-varying current; indeed, we shall see that it is not.

Effect of Shape of Section.

So far as the carrying capacity for magnetic lines is concerned, one shape of section of cores is as good as another; square or rectangular is as good as round if containing equal sectional area. But there are two other reasons, both of which tell in favour of round cores. First, the leakage of magnetic lines, from core to core is, for equal mean distances apart, proportional to the surface of the core; and the round core has less surface than square or rectangular of equal section. All edges and corners, moreover, promote leakage. Secondly, the quantity of copper wire that is required for each turn will be less for round cores than for cores any other shape, for of all geometrical figures of equal area the circle is the one of the least periphery.

Effect of Distance between Poles.

Another matter that Du Moncel experimented upon, and Dub and Nicklès likewise, was the distance between the poles. Dub considered that it made no difference how far the poles were apart. Nicklès had a special arrangement made which permitted him to move the two upright cores or limbs, nine centimetres high, to and fro on a solid bench or yoke of iron. His armature was 30 centimetres long. Using very weak currents he found the effect best when the shortest distance between the poles was three centimetres; with a stronger current 12 centimetres; and with his strongest current nearly 30 centimetres. I think leakage must have a deal to do with these results. Du Moncel tried various

experiments to elucidate this matter, and so did Prof. Hughes, in an important, but too little known research, which came out in the "Annales Télégraphiques" in the year 1862.

RESEARCHES OF PROF. HUGHES.

His object was to find out the best form of electromagnet, the best distance between the poles, and the best form of armature for the rapid work required in Hughes printing telegraphs. One word about Hughes's magnet. This diagram, Fig. 51, shows the form of the well-known Hughes's electromagnet. I feel almost ashamed to say those words "well-known," because although on the Continent everybody knows what you mean by a Hughes's electromagnet, in England scarcely anyone knows what you mean. Englishmen do not even know that Prof. Hughes has invented a special form of electromagnet. Hughes's special form is this: A permanent steel magnet, generally a compound one, having soft iron pole-pieces, and a couple of coils on the pole-pieces only. As I have to speak of Hughes's special contrivance amongst the mechanisms that will occupy our attention next week, I only now refer to this magnet in one particular. If you wish a magnet to work rapidly you will secure the most rapid action not when the coils are distributed all along, but when they are heaped up near, not necessarily entirely on the poles. Hughes made a number of researches to find out what the right length and thickness of these pole-pieces should be. It was found an advantage not to use too thin pole-pieces, otherwise the magnetism from the permanent magnet did not pass through the iron without considerable reluctance, being choked by insufficiency of section; also not to use too thick pieces, otherwise they presented too much surface for leakage across from one to the other. Eventually, a particular length was settled upon, in proportion about six times the diameter, or rather longer. In the further researches that Hughes made he used a magnet of shorter form, not shown here, more like those employed in relays, and with an armature from two to three millimetres thick, one centimetre wide, and five centimetres long. The

FIG. 51.—Hughes's Electromagnet.

poles were turned over at the top towards one another. Hughes tried whether there was any advantage in making those poles approach one another, and whether there was any advantage in having as long an armature as five centimetres. He tried all different kinds, and plotted out the results of observations in curves, which could be compared and studied. His object was to ascertain the conditions which would give the strongest pull, not with a steady current, but with such currents as were required for operating his printing telegraph instruments; currents which lasted but one to twenty hundredths of a second. He found it was decidedly an advantage to shorten the length of the armature, so that it did not protrude far over the poles. In fact, he got a sufficient magnetic circuit to secure all the attractive power that he needed, without allowing as much chance of leakage as there would have been had the armature extended a longer distance over the poles. He also tried various forms of armature having very various cross-sections.

(To be continued).

The Ward Electrical Car Company.—The following has been communicated to us by the Secretary: The first annual general meeting of this Company took place on Wednesday, Mr. E. R. Cummins in the chair. The report and accounts were taken as read. The Chairman then reported that the details of the contract for the construction of the first line of omnibuses and for the charging station had now been finally settled with the Electric Construction Corporation, Limited, and that the work will be at once proceeded with, and also that the Board intended as soon as this line is running to form a sub-company for London to take over the station and omnibuses and to work a large line of vehicles. The Managing Director reported having received an order for an electrical van for trade purposes from a firm who intend to largely introduce them, also that an important tramway company had practically concluded to place a contract with this Company.

UTILISING WATER POWER AT GRENOBLE.

A very striking illustration of the utilisation of water power by electricity in mountainous districts, where it would be utterly impossible to erect factories, is to be found at a paper mill in Moutier, near Grenoble. The generating plant is placed in a small building, situated quite alone in the mountains; turbines obtain their water through steel sheet tubes from a point about 220ft. above, on the Pic de Belledoune, and an overhead conductor of 3½ miles length supplies the current to the electromotor in the paper mill. The following data of the resistances and efficiency will be of interest:

Energy $\begin{cases}\text{dynamo, 300 h.p.;}\\\text{motor, 200 h.p.;}\end{cases}$ revolutions $\begin{cases}\text{dynamo, 240.}\\\text{motor, 300.}\end{cases}$

Highest pressure in overhead conductor, 2,850 volts; largest current in overhead conductor, 70 amperes.

RESISTANCES.

Conductor	3·474 ohms.
Dynamo	
Magnets	0·95 ,,
Armature	0·984 ,,
Motor	
Magnets	0·731 ,,
Armature	0·690 ,,
Total	6·829 ohms.

Electrical efficiency, 83 per cent.; mechanical efficiency, 65 per cent.

Since its inauguration last year the plant has been running day and night without a single hitch, even during the four winter months.

ELECTRIC LIGHTING TENDERS.

The following tenders have been sent in for putting up an electric light installation at the Mullingar District Lunatic Asylum, county Westmeath, from plans and specifications prepared by Mr. W. Kaye Parry, M.A., B.E., civil engineer, 35, Dame-street, Dublin:

	*Contract 1.	†Contract 2.	Total.
Siemens Bros. and Co., London	£2,997	£716	£3,713
Latimer Clark, Muirhead, and Co., London	2,512	555	3,067
Rashleigh, Phipps, and Dawson, London	2,435	629	3,064
Edmundson, Dublin	2,280	525	2,805
W. T. Goolden and Co., London	2,271	633	[illegible]
Fowler, Lancaster, and Co., Limited, Birmingham	1,855	546	2,400
Mather and Platt, Manchester	1,820	490	2,310
B. Verity and Sons, London	1,769	490	2,259
Sharp and Kent, London	1,692	585	2,277
Electric Engineering Co. of Ireland	1,677	413	2,090
Manchester Edison-Swan Co., Limited	1,656	550	2,206
J. D. F. Andrews and Co., London	1,395	555	1,950
Woodhouse and Rawson United, Limited, London	1,357	433	1,790
Electric Engineering Corporation, West Drayton	1,310	445	1,755
Crompton, Limited, Chelmsford	2,310	—	—
Drake and Gorham, London	2,261	—	—
The Gulcher Electric Light Co., Limited, London	2,045	—	—
J. E. H. Gordon, London	1,850	—	—

* Contract 1 is for lighting the whole building by direct current, without accumulators; including fixing and supplying 70-h.p. (indicated) steam engine, working at 60lb. and non-condensing (no boilers); dynamo giving 105 volts and 350 amperes, with belting, switchboards, wiring, etc. (including cutting away and making good walls and ceilings). The whole to be guaranteed for six months. The total number of lamps to be fitted up is 430 of 16 c.p. and 20 of 200 c.p.

† Contract 2 is supplementary to No. 1, and includes countershafting for driving the above-mentioned dynamo, and the provision of smaller one, giving 130 volts and 50 amperes, with a set of 50, 23L E.P.S. cells, together with the provision of switchboards, instruments, and necessary cables complete.

NOTE.—Several estimates were disqualified, probably owing to some ambiguity in the specification as to the meaning of the following expression: "Estimate No. 2 to embrace the works in the supplemental specification, appendix C," which evidently might be taken to mean the inclusion of the whole of both plants, but which has been found to mean an estimate for the accumulator plant only.

INVESTIGATION OF THE STANLEY ALTERNATE CURRENT ARC DYNAMO.*

BY W. B. TOBEY AND G. H. WALBRIDGE.

Before entering directly upon the subject to be presented this evening—*i.e.*, the investigation of the Stanley alternate-current arc dynamo, it may be well to give a brief description of that new and extremely novel type of machine. Descriptions of it have been given in some of the electrical papers during the past spring, but some here may not recall its general mechanical construction. The dynamo is manufactured and sold by the Westinghouse Electric Company under patents granted to Mr. Wm. Stanley, jun.,

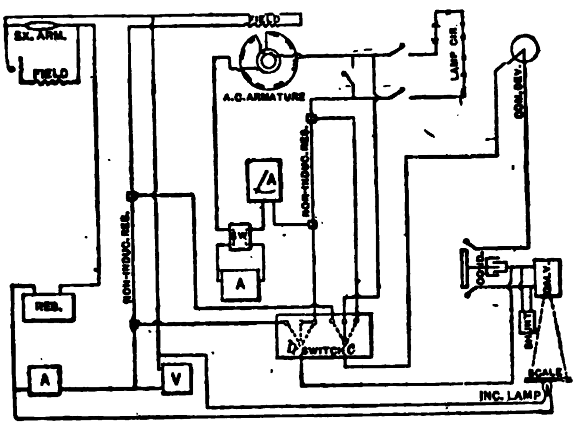


FIG. 1.—A A, Ammeters. V, Voltmeter.

the inventor. Mr. Albert Schmid, superintendent of the Westinghouse Electric Company's shops, deserves much credit for perfecting the machine in detail, and to him is largely due its success commercially. In general appearance it closely resembles the Westinghouse alternate-current constant-potential dynamo, which has become so familiar to all. In fact, the frame, pole-pieces, field windings, etc., for any given size machine are identical, whether for constant current or constant potential. The distinguishing feature between them lies wholly in the form and winding of the armatures. Figs. 12 and 13, showing diagrammatically half-sections of the machine, will aid

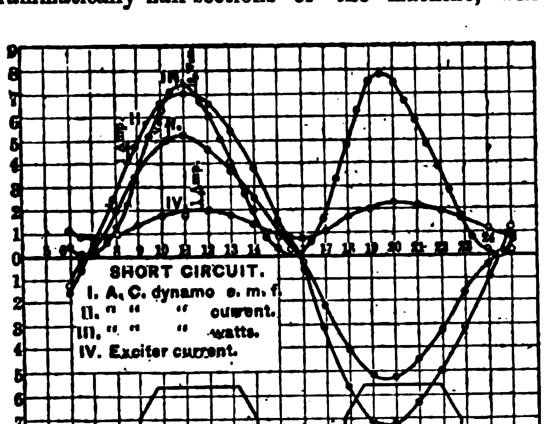


FIG. 2.

us in a description of the armature, which is built up of thin iron plates stamped in the form shown. It will be observed that a number of cores corresponding to the number of poles on the dynamo project radially from the armature, and from the sides of each core project overlapping lugs. The armature coils are not of the original "pan-cake" or oblong flat coil type, placed on the periphery of the armature, but are quite thick, and placed around the core projections. The overlapping lugs serve the double purpose of preventing the coils from slipping off the cores, and also aid in the regulation of the machine. All the armature coils are connected in series and the terminals connected to the two collector rings, upon which

* Paper read before the American Institute of Electrical Engineers, New York.

bear the brushes furnishing current to the line. The field coils are also in series, so connected that the poles presented to the armature are of alternate polarity. The terminals of the field go directly to a small shunt-wound exciter. Thus it is seen that the machine consists simply of an even number of field coils, corresponding to the number of poles on the machine, joined in series, and an equal number of armature coils also joined in series. That from such a simple combination of coils without any external regulating device an almost constant current is obtained for all loads, from short circuit to the maximum

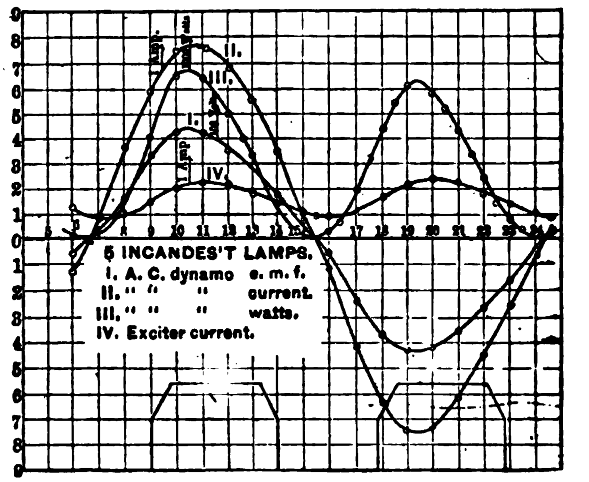


FIG. 3.

output of the machine, seems incredible, but such is the case.

Through the kindness of Mr. Stanley, a complete 40-light plant was sent the writers at Cornell University, at which institution we were then students. Later, the Westinghouse Company made the university a gift of the entire plant. It has been our aim to show how the regulation takes place; also, to determine the actual electrical output of the machine, and from the latter and the corresponding dynamometer readings to calculate the efficiency of the dynamo.

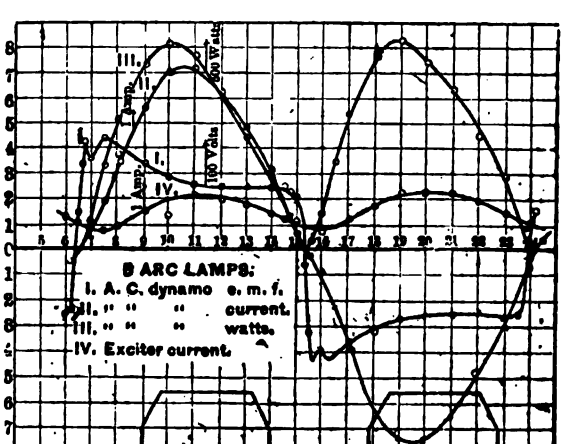
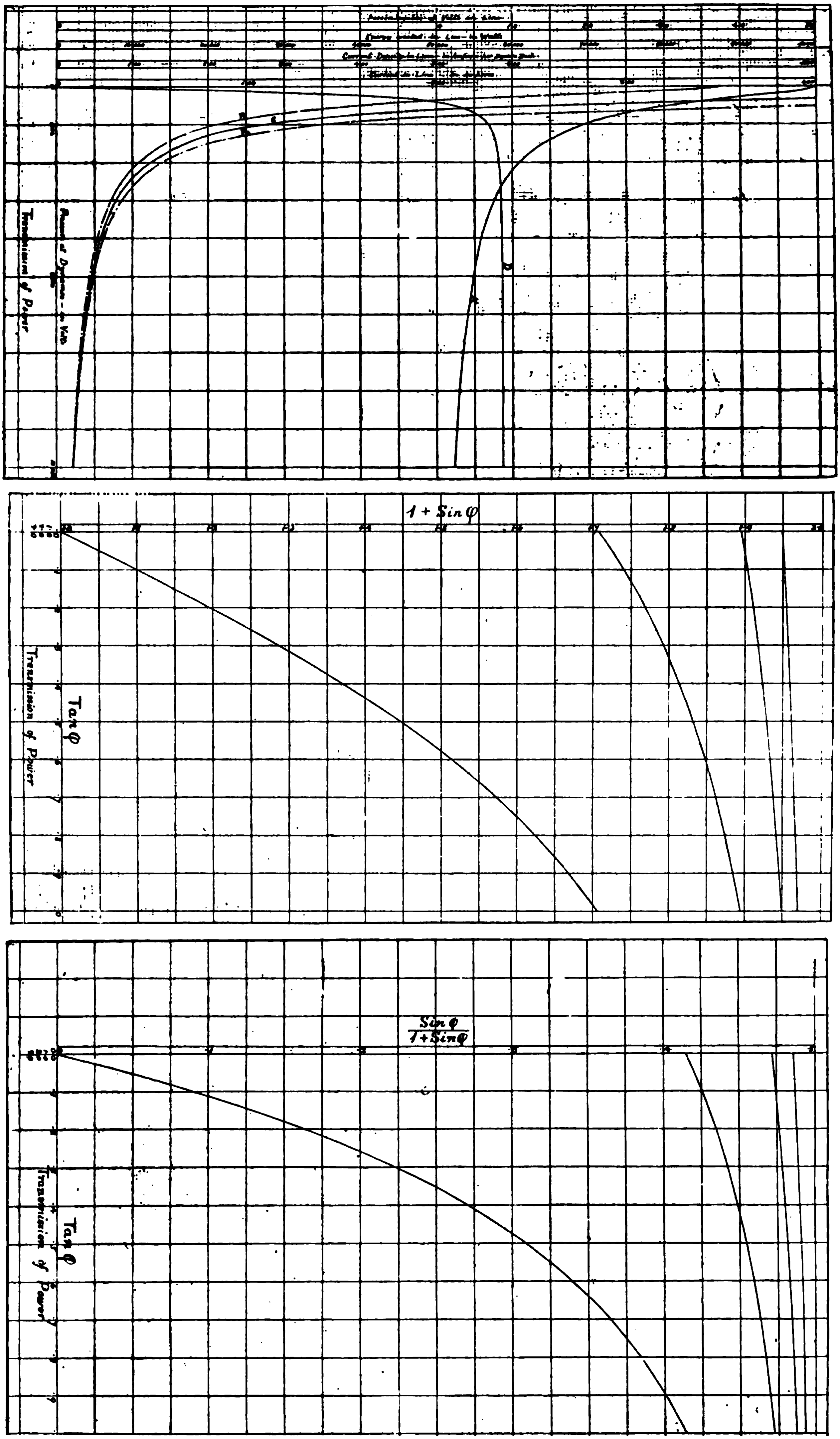


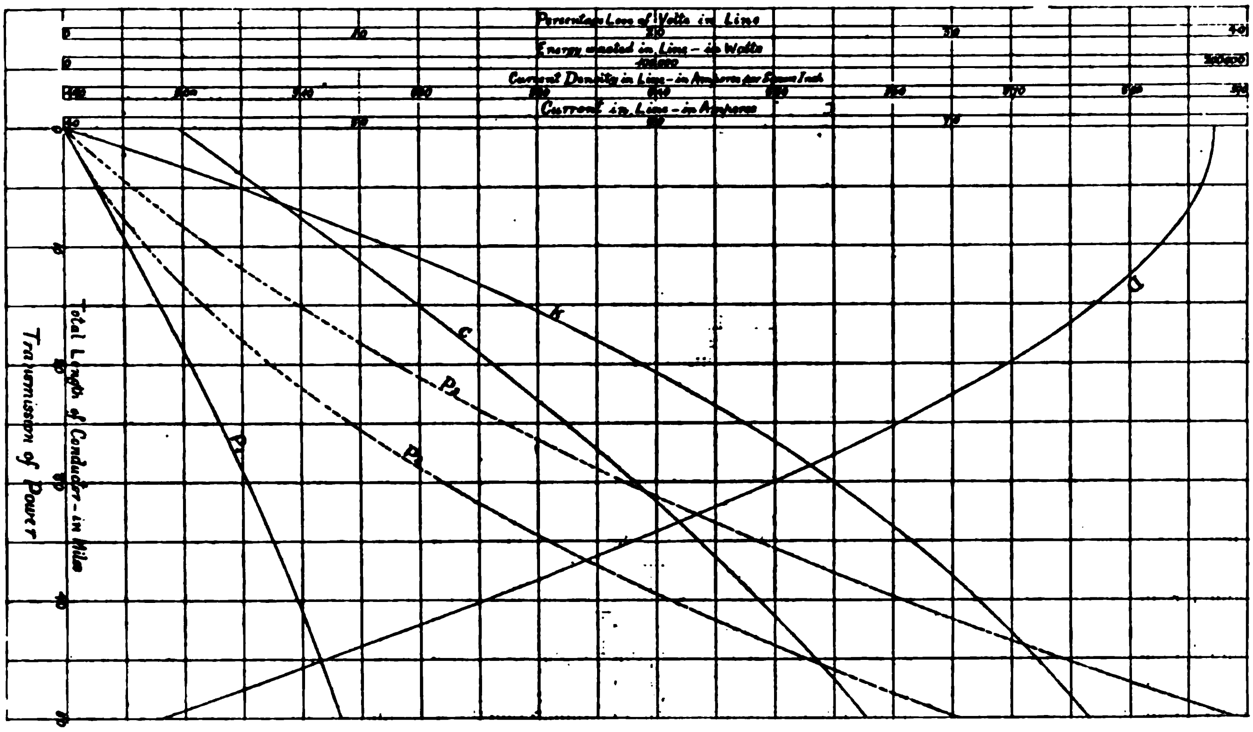
FIG 4.

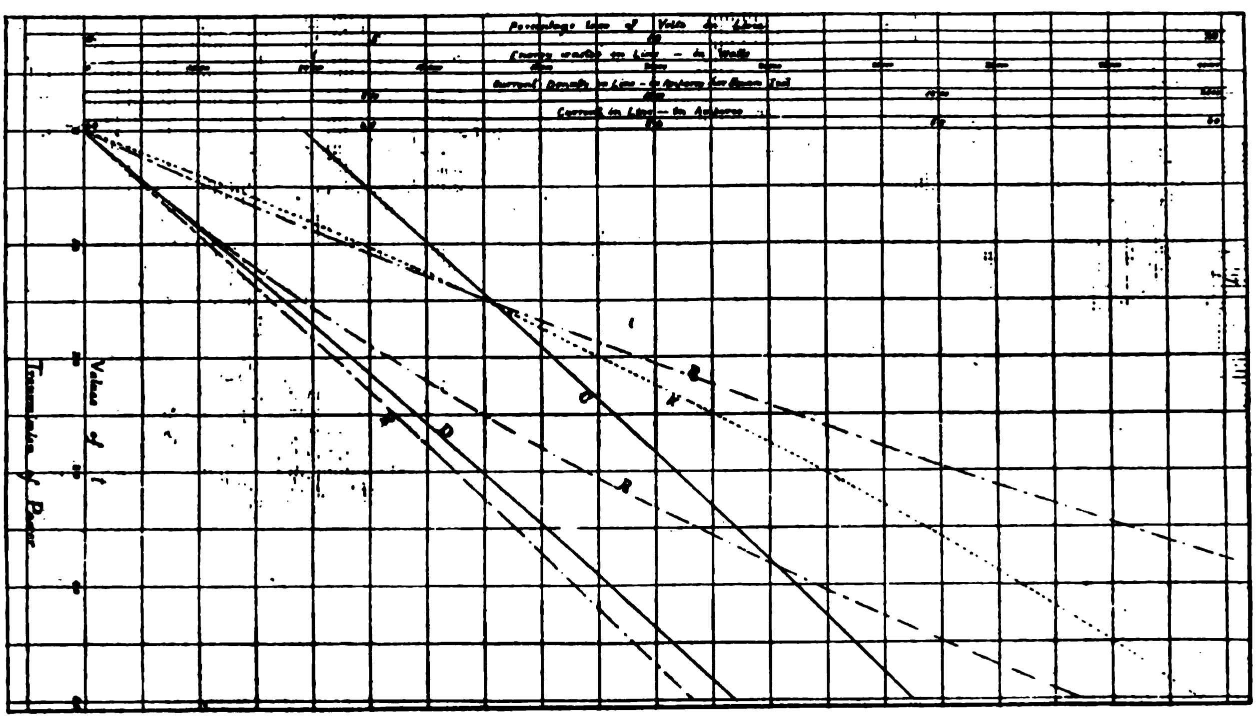
The alternator was mounted on a Brackett cradle dynamometer calibrated to read in watts direct at 1,000 revolutions, the speed at which we were running.

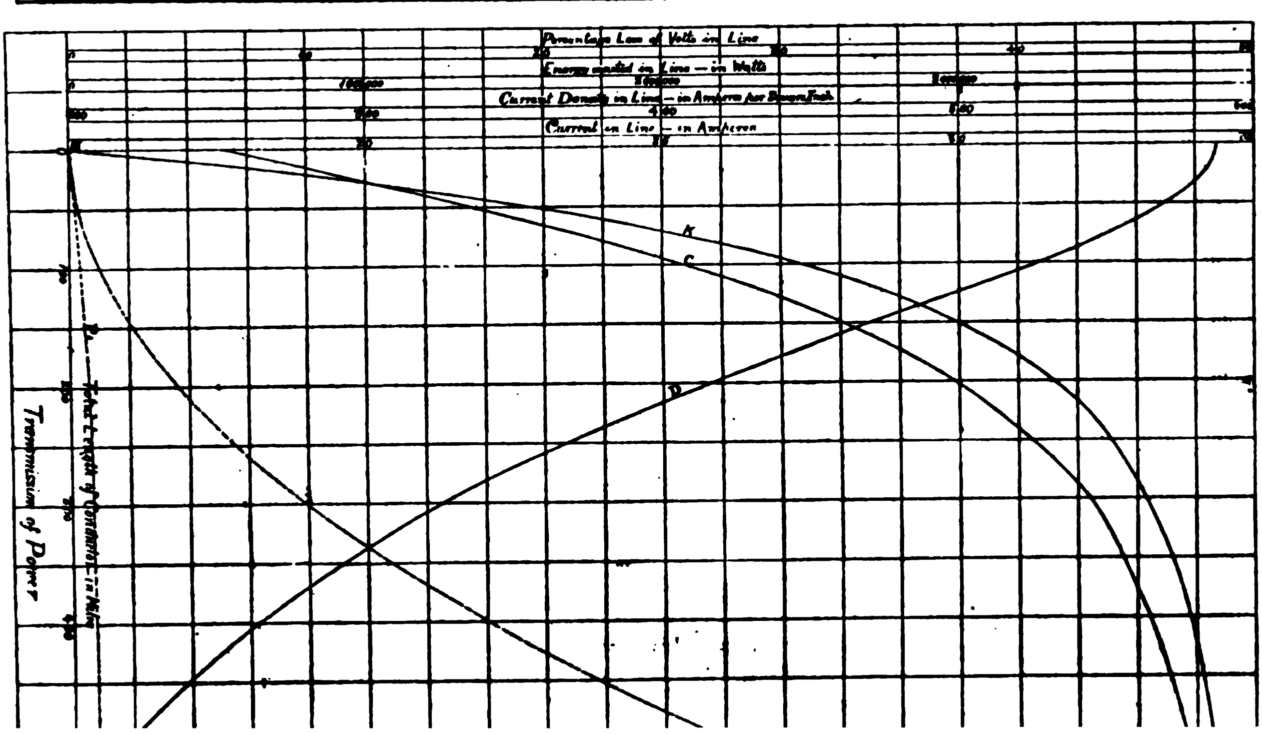
The general method has been to obtain instantaneous values of E.M.F. arc and exciter currents at a sufficient number of points to indicate by curves the performance of the dynamo at every part of a revolution. For this purpose runs were taken with the dynamo at short circuit and with loads of 5, 10, etc., up to 40 lamps. The dynamo was run under normal conditions—viz., at a speed of 1,000 revolutions, and with such excitation as to cause an output of approximately 10 amperes. For obtaining values of E.M.F. at low loads pressure wires were run from the terminals of the dynamo, and for larger loads, were taken from around 10 lamps. At all points where instantaneous values



CURVES ACCOMPANYING MR. KILGOUR'S PAPER ON ECONOMY IN CONDUCTORS.







CURVES ACCOMPANYING MR. KILGOUR'S PAPER ON ECONOMY IN CONDUCTORS.

THE

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All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

TO ADVERTISERS.

Advertisements should be addressed to the Publisher, 139-140, Salisbury Court, Fleet Street, E.C., and should reach him not later than noon of Thursday. **Special Terms** *for a series can be arranged on application.*

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BOUND VOLUMES.

Vols. I., II., III., IV. and V., new series, of "THE ELECTRICAL ENGINEER" *are now ready, and can be had bound in blue cloth, gilt lettered, price 8s. 6d. Subscribers can have their own copies bound for 2s. 6d., or covers for binding can be obtained, price 2s.*

IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

ACCUMULATOR TRACTION.

The question of tramcar traction by accumulators has taken a fresh turn this week, and we think our readers will be thankful to learn how matters seem to stand upon this important point. The electrical world in England has been somewhat anxiously and cynically watching for developments in traction by accumulators, and sundry hints as to unknown depreciation of the battery plates and shakings of head as to the practical outcome of well-known experimental tracks have been all that has come before their notice. Last week an advertisement appeared in the usual papers with reference to the North Metropolitan Tramways, notice being given of a proposed amendment to section 4 of that company's Act of 1890 to the following effect:

> "That application is intended to be made to Parliament in the ensuing session, by the North Metropolitan Tramway Company, for an Act to alter and amend or to repeal the provisions contained in section 4 of the North Metropolitan Tramways Act, 1890, relating to the consents of the local authorities referred to in that section, and to make other provisions with reference thereto, and so far as necessary to alter or amend or repeal the provision of any other Act relating to the company, and to vary and extinguish any rights or privileges which would or might interfere with the objects aforesaid."

This action upon the part of the North Metropolitan Company is both an indication of their determination not to be over-ridden by moribund vestries, and at the same time a very telling commentary upon the criticisms which insist that accumulators for traction cannot pay.

It may be remembered that the North Metropolitan Company having granted the use of one of their lines to be equipped at Barking-road, experiments at first, and now for some time practical running, have been carried on upon this road with the storage cars of the General Electric Traction Company. Two causes, having no relation to each other, have prevented the more extended and permanent use of these accumulator cars on the tramway company's roads. The first of these, the question of cost of maintenance and depreciation of the cells, we will return to presently. The second has been the continued refusal of the West Ham Local Board to accord anything like a reasonable permission to run the electric cars. All endeavours up to the present time of both electric company and tramway company themselves have resulted in the refusal of the West Ham authorities to grant a longer permission than one year, with the condition of enforced removal after only 24 hours' notice. Such a condition as this is absolutely prohibitive for the North Metropolitan or any other company to put down plant on an extensive scale—with the fear of notice of removal at 24 hours' notice hanging over them. They have first applied to the London County Council to learn if this body would grant a seven years' permission for running electric cars, and we learn from the proceedings of the London County Council that this permission has now been granted upon condition of

putting the permanent way in thorough repair and of taking such precautions for the public safety as the Council shall think fit. The North Metropolitan, then, finding it impossible to induce the West Ham authorities to alter their terms, have taken steps to introduce the afore-mentioned Bill into Parliament in the present session, with a view, it may be supposed, of compelling them to give this permission, if the notice itself is not sufficient to force their hands.

The very fact that a large company like the North Metropolitan intend to fight the matter for themselves in Parliament, is itself striking evidence as to whether they do or do not regard electric traction as a desirable thing. It is not to be supposed that they would go so far, and would consider the investment of capital necessitated by the necessary plant and stock which it means, without a good assurance of the profitableness of the undertaking.

We are in a position to state a little more clearly than has hitherto been done what are the arrangements concluded, or likely to be concluded, in this direction. Electrical engineers have been looking for the publication of the balance-sheet of the Barking-road route to enable them to judge of the advisability of accumulator traction. It is doubtful, and more than doubtful, if this balance-sheet will ever be published, at any rate for the period up to the present. The experience which has been gained has been avowedly an experimental experience, and the actual total cost of management, alteration, and depreciation, whether it comes out at 4½d., or even double, if it allows future contracts to be regulated on a paying basis, will, in either case, be lightly bought—and all the while money has certainly been earned. The expenses upon the line have been reduced continually until they are now within the limits from which the expenses upon a considerable scale can be calculated with accuracy. Certain important improvements in the type of traction cell have been introduced, which have had the effect of still further reducing the depreciation on traction cells to within reasonable limits, of which, perhaps, it may be sufficient to say that the prolonged tests show that the combined life of the positive and negative plates equals two years. An important feature in the case is that the makers of the cells, the Electric Construction Corporation, have arranged to undertake the maintenance of the cells, in fair usage, for a definite sum or percentage, a matter which allows the actual total cost—the other factors being already sufficiently closely known—to be now calculated with accuracy. The actual cost of depreciation for a plant of 50 cars we are assured thus comes out at about 1d. per car mile—that is, for maintenance of the cells alone, be it understood.

The other important point, and one which arises out of and takes its possibilities from this action of the makers of the cells, is that of the proposed arrangement between the traction company and tramway company. The North Metropolitan Company, who received the Glasgow Corporation some little time ago and allowed them the fullest facilities of inspection and enquiry, intimated to these latter that they intended to give no more contracts for haulage, but that they contemplated installing their own plant, and would contract for the *maintenance in good order of the electric plant*. This determination is worthy the consideration of both tramway companies and electrical engineers, and solves the difficulties both of management of men, stock, and capital, that would be too likely to interfere in an absolute contract for haulage at so much per car mile—when the electrical men and the tram men would be under separate authority, and other difficulties would also be likely to arise. With the proposed arrangement the electrical company would put down the plant at the expense of the tramway company, and would thereafter contract—according to the length of line, number of cars, and other matters—for the *maintenance* of the electrical part of the installation, and at so much per car mile. The necessary trials and figures are so far settled with both the makers and the traction company, that these latter are able and willing to enter, at the present time, into contracts for 10, 100, or 1,000 storage cars, and to maintain the electrical part in order at a fixed charge according to circumstances per car mile. We are sure all will be glad to hear of arrangements seemingly so promising for the progress of electric traction in England.

PECCAVIMUS.

Yes, and with our eyes wide open too. In large paper mills and in other manufactories where bleaching operations on a large scale are required electricity must, in the future, play an important *rôle*. Our well-known contributor, Mr. Watt, writing on the subject in our issue of October 31st, as was natural, referred to his brother's work in this direction, and maintained that his brother was the pioneer inventor of the method. Mr. Andreoli controverted this statement, and now Mr. Watt returns to the fray. From our point of view little or no good can arise from an extended controversy, which will necessarily lead to crimination and recrimination, and will show how very differently men interpret the same sentences. Our aim in the first place was to once more indicate a direction which might advantageously be exploited by dynamo builders, for dynamos must be used when the process is adopted, as must engines, besides other electrical accessories. The discussion is practically to determine the exact claim to priority of Mr. C. Watt, a claim, which if admitted freely and ungrudgingly, has no influence upon business now, inasmuch as this patent has long since lapsed. We think therefore that it will

NEW COMPANIES REGISTERED.

Weymersch Electric Battery Syndicate, Limited.—Registered by Harwood and Stephenson, 31, Lombard-street, E.C., with a capital of £20,000 in £5 shares. Object: to carry on in the United Kingdom and elsewhere the business of an electric light company in all its branches. The first subscribers are:

	Shares.
A. M. Cardwell, 29, St. James-street, Piccadilly	1
H. Weymersch, 17, Glengarry-road, Dulwich	1
W. S. T. Martin, 17, Melbourne-grove, Dulwich	1
E. C. de Segundo, 7, Victoria-street, S.W.	1
F. Fanta, 10, Moorgate-street	1
C. F. Jones, Inglewood, Upper Norwood	1
Mrs. McKenzie, 21, Talbot-road, Bayswater	1

There shall not be less than three nor more than five Directors. The first are the first two signatures and T. H. and W. A. Cardwell. Qualification: £500. Remuneration to be determined in general meeting.

PROVISIONAL PATENTS, 1890.

November 24.

19033. **Improvements applicable to switches used for electrical purposes.** Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London. (Arthur W. Tourvay Hinde, Australia).

19034. **Improvements in automatical electrical apparatus.** Reginald John Jones and Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London.

19035. **Improvements in dynamos for firing explosive charges or for medical purposes.** Frank William Dodd, 37, Walbrook, London.

19037. **Means of neutralising or controlling the polarity of iron or steel for the protection of magnetic needles from local attraction.** John Sacheverell Gisborne, 14, Oxford-road, Kilburn, London.

19052. **Improved combination of ingredients constituting a compound as an illuminating medium for electric incandescent lamps.** Mervyn Nathaniel Mallison, 166, Fleet-street, London.

19057. **Improvements in electric arc lamps.** William Phillips Thompson, 6, Lord-street, Liverpool. (Ralph Hamilton Beach, United States.) (Complete specification.)

19068. **Improvements in telephone spring jack switches.** John Edward Kingsbury, 24, Southampton-buildings, London. (The Western Electric Company, United States.)

19076. **Improvements in electric safety fuses.** William Morris Mordey, 46, Lincoln's-inn-fields, London.

November 25.

19079. **Electric cables.** John Armstrong, Great Western Works, Bilston, Staffs.

19083. **An automatic electrical latitudinal indicator and ships' course registering compass.** John O'Niel, 6, Livery-street, Birmingham. (Complete specification.)

19106. **Improvements in or connected with combinations of hydraulic, pneumatic, and electric means for obtaining, transmitting, and applying motive power.** Charles Adams-Randall, "Mattapoisett," Bedford-park, London.

19155. **Improvements in electrical storage batteries or accumulators.** Henry Harris Lake, 45, Southampton-buildings, London. (George Elwyn Hatch, United States.) (Complete specification.)

19162. **Improvements in methods of electric welding and metal working.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

19191. **Improvements in and relating to underground electric tramways.** Malone Wheless and Samuel Edwin Wheatley, 77, Chancery-lane, London. (Complete specification.)

19203. **Improvements in the manufacture of thin metal tubes by electrolysis.** Lincoln Hausmann, 46, Lincoln's-inn-fields, London.

November 26.

19239. **Improvements in electric switches.** Henry Barton, 433, Strand, London.

19272. **Electric soldering irons.** Charles Edwin Carpenter, 6, Bream's-buildings, London. (Date applied for under Patents Act, 1883, Section 103, 10th May, 1890, being date of application in United States.) (Complete specification).

November 27.

19308. **Improvements in and connected with electrical distribution of power by alternating currents, and their measurement.** James Swinburne, Broom Hall Works, Teddington.

19315. **Improvements in electric arc lamps.** Harry Nunns, 8, Quality-court, London.

19344. **Improvements in electrolysis in general, and particularly in electrolysis of metals.** Emile Placet and Joseph Bonnet, 6, Bream's-buildings, London.

November 28.

19406. **Improvements in electric current meters.** Eugen Hartmann and Wunibald Braun, 47, Lincoln's-inn-fields, London. (Complete specification.)

19418. **Improvement in electrical tell-tales for twin-screw steamers.** George Hannah, 45, Southampton-buildings London.

19423. **Improvements in apparatus for the electrolytic production of gases.** Eugène Adrien Ducretet, 53, Chancery-lane, London.

November 29.

19467. **Improved electric arc lamp.** John Pitt Bayly, 18, Fulham-place, Paddington, London. (Auguste Wagnière, U.S.A.)

19485. **Automatic railway signalling by electricity.** Hamilton Edward George Earle, 20, Laura-place, Southampton.

19486. **Improvements in telephonic switching apparatus.** Alfred Rolling Bennett, 26, Booth-street, Manchester.

19504. **Improvements in systems of electrical distribution.** Walter Stedman Richards, and George Barker James, 45, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1890.

58. **Incandescent electric lamps.** Gardner. 6d.

761. **Generating electricity.** Dahl. 8d.

2255. **Electric switches, etc.** Macaulay-Cruikshank (Schwabacher). 8d.

5062. **Electric railways.** Depoele. 8d.

14269. **Electric signalling.** Radcliffe. 8d.

15006. **Converting electrical energy.** Kennedy. 6d.

15469. **Administering electricity to the human body.** Imray (The Bethel Electric Medical Baths Company, Limited). 6d.

CITY NOTES.

West Coast of America Telegraph Company.—The receipts for November were £4,350.

Direct Spanish Telegraph Company.—The receipts of the Company for November were £2,722, against £2,497.

Eastern Telegraph Company.—The traffic receipts for the month of November were £58,975, against £60,578 in the corresponding period of 1889.

Eastern Extension Telegraph Company.—The traffic receipts for the month of November were £44,742, against £44,167 for the corresponding period in 1889.

West India and Panama Telegraph Company.—The estimated receipts for the half-month ended November 30 were £2,807, as compared with £3,111 in the same period of last year.

Western and Brazilian Telegraph Company.—The receipts for the week ended November 28, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £5,016.

Interim Dividend.—The Directors of the Brazilian Submarine Telegraph Company, Limited, have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, tax free, for the quarter ended September 30, payable on the 23rd inst.—The receipts of the Company for the week ended November 28 amounted to £6,368.

Removal.—Messrs. Lacombe and Co. inform us that, in consequence of increase in business, they have taken ground floor premises at 7, Carteret-street, Queen Anne's Gate, where they will be able to keep a large stock of lighting carbons, microphone carbons, batteries, plates, etc., for supply of pressing demands on immediate notice. Having lately enlarged their works and added to them an entirely new plant, they are now in a position to accept the largest orders. They have also introduced certain improvements in the make of their carbons, which have now a longer duration than even heretofore, and are extremely clean-burning. We are glad to notice the continued progress of these well-known carbons.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2
Swan United	3¾	5
Crompton & Co., Pref.	—	5½
National Telephone	5	4½
Electric Construction	10	8

NOTES.

Rugby is adopting electric fire alarms.

The Portobello Town Council are quarrelling with the gas company.

Yorkshire College, Leeds.—A movement is on foot to establish a chair of metallurgy at the Yorkshire College.

Bordeaux.—The local gas company has taken up electric lighting, and has introduced it into *its own* offices and the Grand Theatre.

Whitby.—In face of the opposition promised by the Local Board, the Yorkshire House-to-House Company has withdrawn its application for an order.

Waking Up.—Warrington and Birkenhead are considerably disgusted with the light afforded by gas, and the Town Councils are looking into the matter.

Hammersmith.—The Vestry have remitted to their Law and Parliamentary Committee the question of whether or not they shall obtain a provisional order.

Blackpool.—The Corporation have forwarded a request to the electric tramway company that they arrange for their cars to run until 10 o'clock each night.

Lightships.—Experiments are to be made by the U.S. Lighthouse Board with electric lights for lightships. If satisfactory, probably they will be largely adopted.

Richard Hornsby and Sons.—At a meeting of the shareholders of this company on Wednesday, Mr. James Hornsby in the chair, a dividend of 6 per cent. was declared.

Coventry.—The City Council, at their meeting on Tuesday, ordered the corporate seal to be affixed to the memorial to the Board of Trade asking for a provisional order.

Stafford. — Alderman W. H. Peach and Mr. C. H. Wright have been elected chairman and vice-chairman respectively of the Electric Lighting Committee of the Town Council.

Moscow.—A permanent international exhibition has been opened in Moscow. Mr. Emile Cloes, of 122, Cannon-street, E.C., has been appointed general agent for this country.

Southend.—Dr. Hopkinson having recommended that 210 lights be employed at Southend Pier in place of 160, as decided on previously, the Local Board have adopted his recommendation.

Denmark.—In some small towns of Denmark, says a gas paper, more gas is used for heating than for lighting. Wise Danes! Cooking and motive power are the legitimate sphere of gas, but lighting is not.

Glasgow.—The Gas Committee have agreed to lay down in the basement of the Mitchell Library a gas engine, dynamo, etc., to produce current for the lighting of the library, at an estimated cost of £690.

Marriage of Captain Khotinsky.—The marriage of Captain A. de Khotinsky, electrical engineer, of Rotterdam, to Mrs. Fuller, widow of the late P. Fuller, Esq., of Blackheath, was celebrated in London on the 24th ult.

Copper and Nickel.—The ores of both these metals have been lately discovered in Canada in the districts of Algoma, Thunder Bay, Rainy River, and that part of the district of Nipissing lying north of French River, Lake Nipissing, and Maltawa River.

Bradford.—At the last Town Council meeting a member called attention to the exceedingly pleasant manner in which the Borough Court was lighted by means of electricity, and hoped that the Council-chamber would soon be illuminated in a similar way.

Main Laying in London.—The sanction of the London County Council has been given to the Electric Supply Corporation, the Notting Hill Electric Lighting Company, and the Kensington and Knightsbridge Electric Lighting Company to lay mains.

Mine Lighting.—The mine of the Odin (S. Africa) Mining Company is lighted electrically. Messrs. Hornsby and Sons, of Grantham, have recently shipped a 40-h.p. engine and boiler to the works for driving the battery stamps and the lighting machinery.

Glasgow Tramways.—The Corporation have resolved to oppose the application of the Glasgow Tramways Company to the Court of Session for leave to amend their articles of association to allow them *inter alia* to adopt other means of propulsion than horseflesh.

Lancaster.—The contract for lighting part of the Lancaster Waggon Company's works with arc and incandescent lamps has been obtained by Messrs. Paterson and Cooper. There are to be 14 arcs of 10 and 15 amperes each, and 190 incandescent lamps of 16 c.p.

Prof. Tyndall.—We are glad to learn that the report of Prof. Tyndall's illness has been very much exaggerated. It is not the fact that he is confined to the house, and though he has lately been unable to attend to any special work beyond his ordinary correspondence, his health is now steadily improving.

Globe Theatre.—The contract for lighting the Globe Theatre electrically under Mr. Norman Forbes is in the hands of Messrs. C. E. G. Gilbert and Co., electrical engineers, 16, Hanway-street, Oxford-street. By an error of our informant, the name was given last week as Messrs. Dickinson and Co.

Weymouth.—The Town Council having considered the application of the Weymouth Electricity Supply Company for the Council's sanction to their obtaining an order, decided that the town clerk should prepare the conditions under which they should sanction the application and place them before a future meeting.

Leamington.—At the last meeting of the Town Council, a report from the surveyor was brought up stating that the pressure in the light mains had been 11·2 volts on an average since the last meeting. The town clerk was instructed to oppose Messrs. Chamberlain and Hookham's application for an order.

Accumulators.—Mr. Schoop, of Oerlikon, has used a plastic material for secondary batteries, which he obtains by taking three volumes of sulphuric acid of a density 1·250, and adding it to one volume of silicate of soda of a density of 1·180. By the use of this mixture he is said to get very satisfactory results.

Reuter's Telegram Company.—This telegraphic agency have determined to extend their operations, and to establish an international advertising agency in addition to their telegraphic news business. They have also decided to alter their articles of association so as to allow them to undertake telephonic services.

Dorchester.—At the last meeting of the Town Council a discussion took place as to the introduction of the electric light, having arisen on the application of a local company for sanction to their obtaining a provisional order. The Council appeared to be in favour of electric lighting, but nothing was decided, the matter being still under consideration by the General Purposes Committee.

Swinton (Lancs.).—At the last meeting of the Local Board, Mr. Kierby drew attention to the bad quality and insufficient pressure of gas supplied to the district by the Salford Corporation. He declared that in the neighbourhood of Worsley-road it was impossible, after midnight or in the early hours of the morning, to get a gaslight half the size of a farthing candle. At his works he had adopted the electric light.

Vienna.—The International Company's central station here has a capacity of 6,000 16-c.p. incandescents, and this can be increased. Two Ganz alternate dynamos will be used, of a respective output of 220,000 and 360,000 watts. They will both be driven direct by a compound condensing engine. The alternators will be excited by a continuous-current Ganz machine, driven by a Westinghouse engine at 700 revolutions.

Ship Lighting. — We found Messrs. Paterson and Cooper, on a recent visit to their works, busy with a number of ship lighting plants, direct driven with various types of engines. Two of these plants are driven by the little "Tower" engines, and are for 200 lights each; one is driven by a Westinghouse engine, for 100 lights; and another is connected to a small vertical Robey high-speed engine, for 50 lights.

Royal Meteorological Society.—At the meeting of the society to be held at the Institution of Civil Engineers, Great George-street, on Wednesday, the 17th inst., at 7 p.m., amongst others the following papers will be read: "Note on a Lightning Stroke presenting some features of interest," by Robert H. Scott, M.A., F.R.S., and "Note on the Effect of Lightning on a Dwelling-house," by Arthur Brewin, F.R.Met.Soc.

Society of Arts.—On Monday next, Prof. V. B. Lewes will give the fourth Cantor lecture on "Gaseous Illuminants." He will deal with the enrichment of coal-gas by highly carburetted water-gas, the Springer, Lowe, Meeze, Flannery, Stapp, Loomis, and Van Steenbergh processes, and studies in carburetted water-gas. On Wednesday, the 17th inst., Mr. Geo. Davidson will read a paper on "Impressionism in Photography."

Variations in Conductivity.—M. Ed. Branly has found that the resistance of such substances as metal filings may be largely modified by vicinity to discharges from static machines, and that this action makes itself felt at a distance of more than 20 metres. It is said that this modification is considerable, for instance, at the moment when the machine is worked the resistance of the conductor may be lowered from 150,000 to 500 ohms.

Telephone Licenses.—In reply to Dr. Cameron on Monday last in the House of Commons, Mr. Raikes said that he hoped to be able at an early date to announce the decision of the Government with regard to licenses for telephone exchanges. It should be borne in mind that the patents for the more important telephones had not expired, and did not expire until July in next year. We have dealt with the present aspect of the telephone question in another column.

The Fog.—More than one railway accident happened this week during the dense fog with which London especially, and the country generally, has been visited. One at least occurred owing to the engine driver mistaking the signals. We do not think that mistakes like these would be possible with Andrew's and Guy's system of electric fog signals, described lately in our columns, and should like to see this method adopted by the railway companies.

University College, Aberystwyth.—The workshop accommodation of the physical laboratory in the University College of Wales, Aberystwyth, has recently been considerably extended, and arrangements are being made for a course of instruction in electrical engineering. The recent additions include one of Messrs. Crossley's D high-speed engines, specially adapted for electric lighting, a Crompton dynamo (shunt and compound wound), and a Crompton D D arc lamp, etc.

Telephone to Paris.—The arrangements for the telephonic cable which is to connect Paris with London are progressing very satisfactorily. The work on the French side is practically complete; the cable itself, of which 24 miles are required, is being made by Messrs. Siemens Bros., and 11 miles are already manufactured. The laying of this cable will be undertaken by the Post Office authorities at the end of the year under the superintendence of Mr. Lumsden, in charge of the s.s. "Monarch."

City and South of London Railway.—We have given from time to time preliminary details, and later some of the technical drawings of the new electric underground railroad from London Bridge to Stockwell. The line will be opened for traffic in a few days, and we think the graphic account of the running of the line which will be found in another column will prove of interest to readers, most of whom have not yet had an opportunity of personally inspecting this last achievement of nineteenth century enterprise.

Mexborough.—We noticed last week that the Mexborough folk were dissatisfied with their gas supply. This week we learn that arrangements are being extensively made for the introduction of the electric light in the town, in consequence of the gas company not agreeing to reduce their prices below 3s. 6d. per 1,000ft. The electric light is already in use at the local colliery, Denby Main, and at the Mexborough flour mill, and on Wednesday, electrical engineers visited the iron works with a view of its being fitted up there.

Change of Quarters.—Members of the Institution of Electrical Engineers will be sorry to learn that the time-honoured residence of their Institution and its library will probably have to be changed. The matter is one of leases and sub-leases, which cannot be renewed without greater increase of charge than apparently is thought desirable, and we may probably expect to hear of the migration of the offices to one of the electrical coteries in the neighbourhood of Victoria or Princes Mansions, a little further up Victoria-street.

Railway Signalling.—In the House, on Dec. 5th, Sir M. Hicks-Beach told Captain Price that the subject of automatic electric signalling on railways had frequently engaged the attention of the Board of Trade, and further enquiries were now being made. There were many difficulties to be contended with, and all he could say at present was that the matter would continue to receive attention. He might add that the Norton Fitzwarren collision would

not have been prevented had the system as hitherto carried out been in force there.

Smithfield Show.—This annual show opened at the Agricultural Hall on Monday last. There is a capital collection of steam engines by nearly all the best known makers. Amongst others represented are Clayton and Shuttleworth, John Fowler and Co., Hornsby and Sons, Edward Humphries, Marshall's, Ransomes, Sims, and Jefferies, Robey's, Ruston, Proctor and Co., and Barrows and Co. Messrs. Priestman show one of their portable and fixed oil engines, which are finding favour with electrical engineers for use in isolated installations.

Montevidean Telegraph Company.—At an extraordinary general meeting of the Montevidean and Brazilian Telegraph Company, held on Wednesday, at the offices, the resolutions passed at the meeting on the 25th ult. were unanimously confirmed, on the motion of the chairman, Dr. Cameron, M.P., seconded by Colonel Macaulay. These, as will be remembered, were for winding up the company voluntarily, and approving an agreement with the Western and Brazilian Company for the transfer to that company of the whole of this company's undertaking.

Carlow (Ireland).—At a meeting of the Town Commissioners on Tuesday, the offer of Messrs. Gordon and Co., of 11, Pall-mall, S.W., for the lighting of the town by electricity, was unanimously accepted. For the last two weeks the company have exhibited three arc lights in the principal streets, and a few incandescent lamps in some of the biggest shops of the town. The result being satisfactory, the authorities have decided to ask the company to continue the temporary lighting at the expense of the town until the arrangements for the permanent lighting are completed.

Joists.—We have received from Messrs. Measures Bros., of 57, Southwark-street, S.E., a handy little pocket-book, giving the figures for the safe distributed load on various spans, and also giving the strength of steel joists as compared with iron. Figures are given as to the dimensions of different sections, with their weight per foot and the lengths in stock. The type and illustrations are very clear for so small a book, which will almost go in the waistcoat pocket. We think our readers, especially those engaged in central station construction, will find this book very useful, and will thank Messrs. Measures for issuing it.

Automatic Telephones at Frankfort.—A new patent automatic telephone made by the Mix and Genest Company, Berlin, will be exhibited next year at the Frankfort Exhibition. By means of this very ingenious instrument the public will be able to converse with subscribers to the telephone exchanges by insertion of a small coin, and if the subscriber who is wanted is already engaged the money is returned automatically. At this week's sitting of the Electrical Society, at Frankfort, the chief manager, Herr Oscar V. Miller, pointed out some of the most interesting features of the coming exhibition, and, amongst others, dwelt upon the automatic telephone at some length.

Electric Construction Corporation.—We give a full report of the meeting of this company in another column. There was a considerable amount of discussion on various points, but in the end the several resolutions as put from the chair were unanimously carried. There was some manifestation of alarm at the formation of subsidiary companies to work the foreign patents, which was apparently quieted by the answers of Mr. J. S. Balfour, the deputy chairman. Mr. Mander endeavoured to get Mr. Parker, of Wolverhampton, elected on the Board, but whilst cordially agreeing in the expressions of esteem for that gentleman, the directors set their faces against the proposal.

Wolverhampton.—At the meeting of the Town Council on Monday, a report was brought up from the Water Works Committee recommending that the works at the Cosford pumping station be lighted by electricity, and that a dynamo be laid down capable of lighting 80 16-c.p. lamps, at a cost of £350. In moving its adoption, Alderman Wright said that if petroleum lamps were used the entire cost of lighting would be about £71 per annum, whereas the cost of lighting by electricity would be about £96 per annum; but, after deducting the cost of the renewal of lamps, it was estimated that the electric light, while much greater and more convenient, would not in a couple of years exceed that provided by oil. The report was adopted.

Barnet.—Mr. Joel and the Local Board are in correspondence as to the termination of the contract for lighting. Mr. Joel, or rather his solicitors, have pointed out that it was part of the agreement that the Board should support his application to the Board of Trade for a license or a provisional order; and had this not been understood, he would never have undertaken the lighting of the district. In view of the fact that he had spent £2,500 in perfecting the plant, and that the Board had refused to assist him to obtain the necessary powers under the Board of Trade, he was entitled to ask the Board either to pay compensation or to take over the works, valued at £7,000, or else to renew the contract and assist him to obtain an order next year.

Welding Plant.—An electric welding plant has been erected at Messrs. Lloyd and Lloyd's, Coombes Wood Tube Works, and was inspected recently by Mr. W. H. Preece and Mr. Ashton, of the Royal Laboratory, Woolwich. The process used is the Bernardos, in which the welding is done by an arc, the sole right for the use of which has been acquired by Messrs. Lloyd and Lloyd. The firm in question have already applied the process in the manufacture of various articles in current demand, and they are also experimenting with it in other directions. They have purchased the engines used at the French Exhibition for electric lighting in order to drive a much larger set of machinery, which they are completing as rapidly as possible.

Post Office Lighting.—The lighting of the post offices by electricity is steadily progressing in all parts of the kingdom wherever the machinery can be economically introduced, and all new buildings are receiving the light as they are built. Glasgow post office has been lighted since 1884. Liverpool is nearly ready, and will be lighted up at Christmas. Birmingham post office is entirely fitted with electric light, driven direct, and running night and day. No gas whatever is used in this post office. Newcastle post office is lighted up from the local electric light company's mains. In London, the General Post Office (East and West buildings) and the Post Office Savings Bank are all lighted. Others, in various parts of London and the provinces, will be lighted as the opportunity occurs.

Museum Lighting.—In the House of Commons, on Tuesday, Sir G. Campbell asked as to the lighting of the Natural History Museum by electric lights. In reply, Mr. Jackson said that temporary arrangements for electric lighting had occasionally been made by societies who had

been allowed the use of the museum, but until further experience had been obtained of the effect of evening opening at the British Museum it was not proposed to take up the question of making a permanent installation for electric light at the Natural History Museum. In answer to a further question, Mr. Jackson said that the experience at the British Museum in reference to evening attendance there was not extremely satisfactory, because, whereas in February the numbers averaged 635, these fell in March to 367, and had continued to fall since, until in November it was only 145.

The Telephone in the North.—The National Company's Sunderland management has issued a notice to the effect that from the first day of next year the subscription will be reduced from £12 to £10 per annum for an exchange connection within one mile. The trunk line tariff will also be revised from the same date, and subscribers will be able to communicate to distant towns at nearly half the cost they have been charged up to the present time. For any distance not exceeding 25 miles the charge will be 3d. for three minutes' conversation, and so on in proportion to distance, a call from 75 to 100 miles being charged 1s. The company has now 22,743 exchange lines, besides nearly 5,000 private lines; its exchanges number 272, and its call offices 526. The number of instruments under rental in England has reached 99,000.

Lighting Powder Works.—The powder works of St. Médard-en-Jalle have been lighted electrically by the firm of Sautter, Harlé, and Co., both arcs and incandescents being used. The conditions of the lighting arrangements were difficult to fulfil, as places 90 metres away from the generating station had to be lighted with incandescents, the E.M.F. having to be maintained constant at 110 volts at the end of a line of 45 mm. square section, whilst the current might vary from 0 to 120 amperes. The dynamo is extra compound wound, there being two windings, one in series, the other in shunt separately excited, at a constant pressure, by an independent dynamo. The dynamo speed is 800 revolutions, and it works 18 out of the 24 hours with a variable load. Two pilot lamps, one coloured green and the other red, placed in the machine-room, show any variations in pressure produced by variations in the speed of the exciter.

Death of M. Armand Bede.—*L'Ingenieur Conseil* announces the death, at the age of 31, of its editor, M. Armand Bede. He had engineered installations in Italy and Russia, from whence some three years ago he had to return to Brussels owing to ill-health. Leaving the Polytechnic School at Brussels in 1880 with the diploma of mining engineer, he assisted in putting up the first telephonic circuit in that town. Subsequently he was employed by the International Company in erecting telephone lines in Milan, Odessa, and Moscow. Having been manager of the exchange at the latter place for some two years, he returned to Brussels, where, in partnership with his father and brother, he carried out much important electrical work, at the same time writing a good deal for the above-mentioned journal. He is much regretted by his associates and friends, by whom he was esteemed as a frank, upright, and sympathetic man.

Society of Engineers.—The annual dinner was given at the Holborn Restaurant on Wednesday. The president, Mr. Henry Adams, occupied the chair, and amongst a large company present were Sir Robert Rawlinson, Sir John Fowler, Sir Benjamin Baker, Sir J. N. Douglass, F.R.S., Prof. Unwin, F.R.S., Mr. Perry F. Nursey, Mr. Arthur Rigg, Prof. Robinson, and Mr. A. T. Walmisley. In proposing "The Society of Engineers" the president said that during the past year the number of members had increased 8 per cent., exclusive of honorary members, and the attendance at the meetings had increased by 10 per cent. Among the honorary members who had recently been elected were Lord Armstrong, Dr. Anderson, Sir B. Baker, Lord Brassey, Sir Jas. Douglass, Sir John Fowler, and Sir Wm. Thomson. In concluding his remarks he paid a well-deserved compliment to the energy of the secretary, Mr. Pryce-Cuxson. Mr. W. N. Colam has been elected president for 1891.

Edinburgh Exhibition.—With regard to the guarantee letters held by the British Linen Bank, the Court of Session have made an order that the bank shall forthwith deliver the letters to the liquidator under reservation of all questions of preference and security over the guarantee fund and the letters, and that, as a further safeguard, a clause shall be added to the order to the effect that delivery has been made under the special declaration that the British Linen Company Bank shall not be prejudiced by having parted with the letters. In connection with Mr. Lee Bapty's arrest, the Court of Session at Edinburgh have granted a reduction of the bond, signed by the exhibition refreshment contractor as security for Mr. Lee Bapty's guarantee of £500; so that the late manager at Edinburgh can proceed to Jamaica with a light heart. The liquidator has issued a circular to the guarantors stating that the bank have handed over to him the letters of guarantee in accordance with the decision of the Court, and requesting immediate payment of the moneys guaranteed. We hope, therefore, that the liquidation will now be effected peacefully and speedily.

Barnsley.—At a recent meeting of the Town Council, the electric light contract with the Westinghouse Company having been read, Mr. J. H. Bailey asked if the clause insisting that the materials so far as possible should be made in England, was put in because the committee were of opinion that better materials would thus be obtained? Alderman Blackburn said it was done to satisfy popular feeling as much as anything. Mr. Wray said some of the opponents of the scheme had made a point of the fact that work was likely to go out of the country. They had mentioned that fact to the company's representative, and as he seemed willing that all the material, with the exception of the dynamos and engines, should be obtained in England, they thought it might as well be put in the contract. Alderman Blackburn said the contract was only going for approval, and they might find, on its return, that the clause had been crossed out. Mr. J. H. Bailey did not quite see the necessity of the clause, so he moved as an amendment that the matter should be left entirely in the hands of the contractor. His amendment was not seconded, however, and the minutes were confirmed in their entirety.

Stopping Machinery.—In a description of the mills of Messrs. Horrocks, Crewdson, and Co., at Preston (Lancs.), a correspondent of the *Warehouseman and Drapers' Trade Journal* says, speaking of the machinery dealing with cotton in what is called the "sliver" form: "A most important thing in connection with the process is that the frames must not be allowed to work even for a moment with one or more of the slivers broken, otherwise the count of the yarn would become irregular, and to avoid all risk of this, valuable mechanical appliances have been devised. The

latest is an electric stop motion patented by Messrs. Howard and Bullough, of Accrington, and to such automatic perfection has this machine been brought that if one of these delicate films should chance to break, the frame would instantly stop dead. The principle of this electric stop motion is as simple as effective. When the sliver is passing between the two iron rollers it necessarily keeps them apart, but when the cotton breaks they come together, and thus an electric circuit is completed, to which the current is supplied by a small magneto-electric machine. Another equally simple motion is provided for stopping the frame when the can is full."

Accumulator Cars.—The snowstorm last week made practically no difference to the running of electric cars. While the poor horses were struggling along with clogged feet, the accumulator car sped on its way with ease. The conditions under which the cars at Barking-road are charged and discharged are very carefully regulated, and the effect is seen in what seems to be the far greater economy of these cars as compared with the Birmingham cars. The grades at Birmingham are, indeed, in places, very much heavier, but the chief obstacle seems to be the adoption of the bogie cars on the Birmingham tram lines. At any rate, the passenger capacity at Barking is 52, and at Birmingham the same, or even one or two less, and the mileage run by the former is within 10 per cent. of the latter, yet the coal consumed at Barking, if the figures in our possession are to be relied upon, is 5½ tons per week at Barking, against 21 tons at Birmingham, which, even considering the greater mileage, heavier gradients, and cheaper coal, leaves a great difference in cost of fuel. The Barking cars are discharged at a maximum of 74 amperes, down to a usual 30 amperes; while at Birmingham the current is nearly double, running from 140 maximum to a usual 100 amperes.

The Telephone in Walsall.—Unless the telephone companies show a disposition to lower their prices, and give their customers increased facilities, they may expect in most of our large towns something of the nature of the following, which is taken from the correspondence columns of a Walsall paper. A Mr. Leckie writes that if the present company at work there offer an all-round charge of £5 to cover an area a mile square, they will get plenty of subscribers, but if they don't, he has ascertained that with a capital of £2,000 to £3,000 there could be established in Walsall 200 to 300 connections with subscribers, with full plant equipment, and at £4 or £5 a subscriber. That the entire working expenses, maintenance, and allowance for depreciation would leave at least 10 to 15 per cent. profit; while the working staff could go on fitting up new connections without extra capital or outlay, as they might be required. At a low figure like this every trader and manufacturer, and the principal shopkeepers and private residences, would be connected, and 300 subscribers is considered not a sanguine expectation. Before going into the formation of a company, which he thinks had better be a co-operative one, where all the profits would go to the subscribers, Mr. Leckie deems it advisable to await the best proposals the old company may be advised to make to the trade and town. Nothing above £5 would ensure success. It is the price that determines success or failure in Walsall. £5 will pay the company well. They need expect monopoly no longer. In Sheffield and other places movements are going forward to get cheap telephones for themselves, owing to the past bad and dear services of the monopolists. Why should Walsall longer be without telephonic facility?

An Unfortunate Matter.—Messrs. Mappin Bros., of 220, Regent-street, W., write as follows to the *Times*: "We are among the unfortunate persons who have been induced to employ a public electric lighting company, and we feel sure that what we are about to say will be useful to others who contemplate similar action. For hours at a time, when at first we had been depending on no other means of lighting our premises, the company (in our case the London Electric Supply Corporation, Limited) has from choice or mismanagement (we do not know which) given us no light at all. This conduct reached a climax with the destruction of the London Company's premises by fire (we hear this originated in their own cables) when it transpired that they had no reserves, and we, with other of their consumers, were without electric light for fully a fortnight. The light has been again supplied, and during this dark weather, and at a season when we are very busy indeed, the supply of this wonderful electric light is of the most fitful character, and comes on and off just presumably (as we can get no explanation from the company) as our suppliers think fit. We think that you and a number of your readers will agree with us that it is a monstrous thing that any license should be granted to a corporation professing to supply the public with what it so obviously does not possess or cannot control, and we write this in the interest of a large section of the public who might be (as we have been) put to great expense and enormous inconvenience owing to what can only be described as (to put it mildly) the utter incapacity of such electric lighting companies." We have commented on this letter elsewhere.

Electric Lighting in London.—In the House of Commons last Tuesday, Mr. R. Chamberlain asked the President of the Board of Trade whether his attention had been called to the long-continued default of the Chelsea Electric Supply Company to furnish the statutory current of 100 volts, and to the serious loss of illuminating power sustained by consumers in consequence; and whether he would take steps to compel this company to keep faith with the public or to forfeit their concession. Sir M. Hicks-Beach replied that last winter the hon. member complained to the Board of Trade of the deficiency in the standard pressure of the current supplied by this company. The Board of Trade communicated with the company, and were informed that the cause of complaint had been removed. Under the regulations imposed upon the company under their order, they were bound to declare to the consumer the constant pressure at which they proposed to supply him with energy, and the variation from the pressure so declared must not exceed 4 per cent. under a penalty not exceeding £5 for each default, and a daily penalty not exceeding £5 so long as the default continues. If the regulations were not complied with it was open to the consumer to proceed against the company for penalties. Mr. R. Chamberlain asked whether the right hon. gentleman's attention had been called to the fact that the variation mentioned was taken advantage of in order to supply the consumers not with an average of 100 volts but of 97, in that way taking advantage of the concession of the Board of Trade. Sir M. Hicks-Beach said that however that might be, if the company were in default the consumers had their remedy. It was not for the Board of Trade to enforce the law. Mr. R. Chamberlain asked if he were to understand that they had no remedy unless the company got below 96, the 4 per cent. referred to in the answer just given. Sir M. Hicks-Beach replied in the affirmative.

EXPIRY OF BELL TELEPHONE PATENT.

The date that has been so long looked for in telephone circles has at last come this week, and on December 9th the famous Bell patent for magneto telephones expired, leaving what is perhaps the most wondrous discovery that science has yet made open and free to the world. The natural and immediate result of this will be a rush to the manufacturers for telephones to be erected on private and

Free Telephone Set.

public lines throughout the whole country, and, indeed, we are assured that this rush has already commenced and thousands of instruments are being packed off, while enquiries are pouring in every day.

There must, however, be no mistake about how the matter stands. It will be remembered that the original and world-awakening patent of Prof. Bell's was for a magnetic telephone consisting of a magnet, a coil, and a

Mix and Genest Spoon Telephone and Transmitter.

vibrating diaphragm. It is this, the most necessary and the master patent—the Bell's magneto receiver patent—that has now expired, and this fact at once puts a vast amount of telephonic work at the disposal of the public. But this does not throw the whole system of telephonic exchanges also open. The Bell telephone, as all know, certainly enabled persons to converse by means of two exactly similar instruments, but was not able to carry out all that had been expected until the introduction of the separate transmitter or microphone. This the original invention of Prof. Hughes, has in the form used in the telephonic exchanges been fought under what is termed the master patent of Edison for carbon transmitter. We have never considered this patent to be really tenable, but the monopoly has been upheld by it, and it would certainly not be worth while contesting now, as this patent also expires in July, 1891. Therefore, although it is possible after this week to manufacture and sell telephones of the magneto Bell pattern, it will not be until July next that systems embracing the full utility of the invention for long-distance work and for large exchanges will be possible. Even then the type of loud-speaking perfected transmitters, known as the Crossley or the Gower-Bell, do not run out for another two years, and although the basis of the whole telephonic system will be open, yet the holders of the later patents may be expected naturally to make the best use and the best fight they can with the material still left to them.

The state of the matter then is simply this, that anyone can now make or use the Bell telephone without special transmitter, and although this telephone does not make

Spoon Telephone in Use.

such an efficient and loud-speaking instrument without the transmitter as with one, it will be found that the key to the monopoly hitherto existing has been lost, and monopoly will no longer be possible.

There is a distinct advantage in having the carbon transmitter, and as this also will be free in another six months or so, it is evidently the best way for intending users to make arrangements in their apparatus, instruments, and lines for the carbon transmitter to be inserted, but for the present to leave it out, and use the telephone in its original simplicity.

We have had a look round at some of the outside makers of telephones to find out how the lapse of the patent will affect them. Messrs. Paterson and Cooper at one time had

Mix and Genest Transmitter.

an enormous business in the manufacture of the telephones, but for some years their work in this direction has entirely subsided. Now that they are able to supply telephone installations out and out for customers, they will take up the manufacture once more, and it is expected that the business will grow to considerable dimensions again

The International Electric Company, who are the English agents for the Mix and Genest Company, of Berlin, are laying themselves out for the satisfaction of an enormous

demand for telephones, of which they are already beginning to feel the effects. One of their patent spoon-shaped telephones had just been fitted up in their office as we called on Tuesday, the day of expiry, and already over 200 telephones had been sent out all over the kingdom, mostly for private installations, and enquiries were coming in at the rate of 50 or 60 a day. A

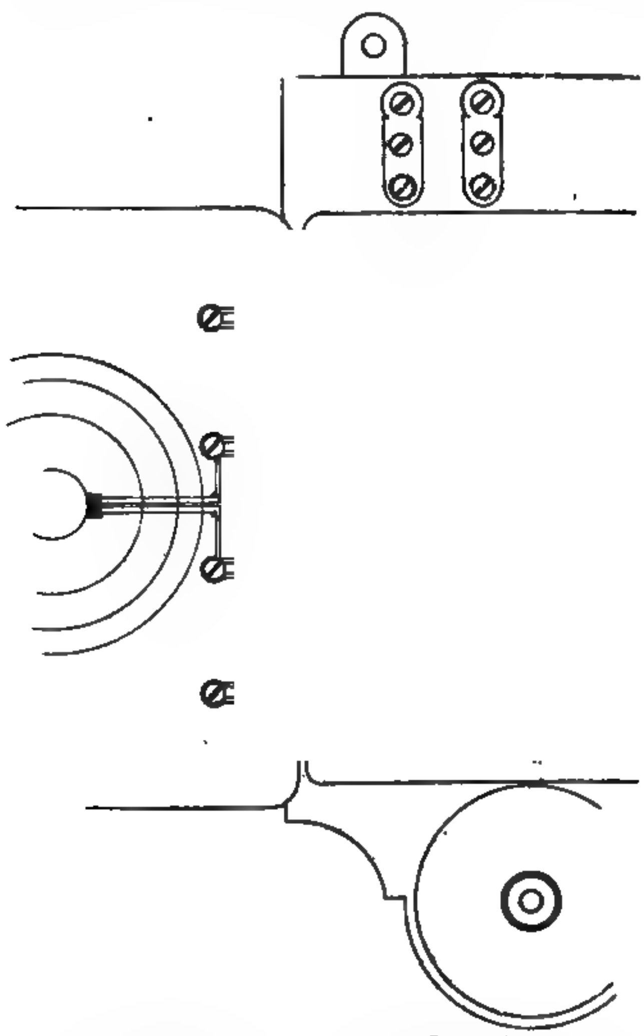

Diagram of Dummy Transmitter Connections.

special telephone set has been manufactured, of which we give an illustration. In this instrument at present, a magneto telephone is inserted in the transmitter, and the transmitter wire is simply led to a dummy screw, as shown in the first diagram. These telephones will be sold outright and guaranteed free of all royalty. To each set of

Line Selector for Small Exchanges.

telephones a microphone will be supplied free of charge in July next, when the transmitter patent expires, and by unscrewing the telephone diaphragm and inserting the microphone in its place, and joining up the wire abovementioned to its proper screw, the telephone will be converted into a microphone set. The spoon-shaped telephone, which have been so greatly used in Germany, will be also sent out; in these the receiver and transmitter are mounted on one bar, and the ear-piece comes to the ear as the mouthpiece comes to the mouth, and listening and speaking can be carried on at the same time and in any position. A special feature which is being introduced by this company is that of the "line selector," an auto-

Diagram of Connections with Transmitter.

matic exchange switch, which we also illustrate. These miniature switchboards enables a certain number of subscribers or speakers to speak to each other without the necessity for a central station by themselves connecting up to the desired line. The "line selector" is made in any number from four or five up to 60 stations, and is in use in Germany in many important establishments. For instance, the International Bank at Berlin has a set for 29 instruments; the Dresdener Bank, Berlin, 24 instruments; the Berlin-Erfurt Railway Company's general offices, 54 instruments, and so forth. The company have specially laid themselves out to supply the demand that is now likely to arise, and have ready supplies sufficient to satisfy very large demands of instruments, which are arranged for all practical purposes. They have also some new and interesting types of multiple switchboards of a simpler type than those now in vogue, which may be expected to come into general use, but as these necessitate the use of the transmitters for central exchange work, we need not further refer to them at the present juncture.

On enquiry at the General Post Office we find that the Post Office authorities do not intend to take any steps with reference to the telephone at present, but will leave any action that may be considered necessary until the expiry of the Edison transmitter patent in July.

Huesca (Spain).—An installation of 200 incandescents and two arcs has been put up here by Don P. Palacios, of Saragossa.

A RUN ON THE CITY AND SOUTH LONDON ELECTRIC RAILWAY.

The City and South London Electric Railway, having already been formally opened by the Prince of Wales, is having the finishing touches put to it, and we are informed that in another few days, probably starting on Monday week, the trains will begin running for the public. We can quite believe that this time the prognostication will be correct, for the trains have been running now for some time for tests and practice, and everything seems to go very well indeed. The machinery is practically in full working order, and the trains, loaded with sacks of gravel to represent 100 persons of 12 stone each, have been running regularly every weekday from nine o'clock in the morning till six at night. When the line is opened the trains will be run with a five minutes' service from six in the morning till half-past 12 at night. We have recently, through the kindness of the engineers connected therewith, had an opportunity of seeing the line in full working order, of riding in the trains, and of inspecting the finished machinery at Stockwell.

The Terminus and Lifts.

The City terminus is, as most of our readers know, almost exactly opposite the Monument of the Great Fire of London. It is rather a handsome building, of red brick and stone, and will open with broad gateways upon the road. The inside of the stations are neatly and brightly decorated, white glazed bricks being used abundantly. The lifts are now in full working order. These are made by Sir W. G. Armstrong, Mitchell, and Co., and run up and down a huge well shaft at each station. Each lift is half of an octagon, with seats along one side for ladies, and is capable of holding with ease 45 passengers, or up to 60 at a crush. The descent is not noticeably slow, and is even and pleasant. The stations are light, large, and well arranged. At the time of our visit a dense and penetrating fog had shrouded the London streets, to which the comparative purity and freshness of the atmosphere underground was in striking contrast. What is seen upon arrival on the platform is not much and is not complicated. In the distance the small dark round tunnel with dim lights flickering. The platform is low, and one set of rails only are seen, as the other line goes by another tunnel. These rails are the usual gauge, and alongside one, about 6in. distance, is fixed the conductor rail. This is a thick bar of solid steel about 1¼in. square, carefully connected with fish-plate junctions end to end. At the terminus a pair of rails leads off by a pair of points to a short distance, on which stands the spare locomotive for connecting to the train on returning on its backward journey; the signals are seen in the distance, and this is all.

The Train and Carriages.

Presently the train is heard approaching, it issues from the little tunnel, slows down and stops easily at the platform. The engine is detached, the spare locomotive is backed up, the coupling is effected in the simplest manner by the backing of the locomotive, which carries a coupler with a bell-shaped opening, into which the bar of the carriage slides easily and the shunter drops in a steel key. Three carriages are attached to each train, sufficient to carry 120 passengers, one carriage being for smokers. The carriages inside are much like a long tramcar or a good second-class railway carriage, having the seats arranged lengthwise, with padded cushions and polished woodwork. Electric lamps are arranged in round glass containers above, but are not yet in use. At first they were intended to be supplied from the main conductor, but owing to the fluctuations it has been deemed better to have a separate supply, and we are informed that this is now arranged to be done by a set of accumulators carried in each train and charged at the generating station. The train starts with an easy motion, and with a roar and a rush plunges into darkness. The speed is obtained in a very few seconds, aided by the gradients, which are made to assist the starts. The carriages are most comfortable, and much roomier than might be supposed; there is plenty of room for a tall man wearing a silk hat, and on sitting down there is more than ample room for passengers' legs. There is more noise than might be expected, owing probably to the close proximity of the roof of the tunnel, and it would be difficult to carry on a conversation. However, as English passengers do not converse much, but read, in a railway train, this will not be much noticed.

On the Locomotive.

The locomotive itself is a neat and clean specimen. There is ample room for the men to stand upright and move about, and there is little to do compared with a steam locomotive, though it naturally requires a careful driver at any time, and doubly so while the system is new. The motor is underneath the floor of the engine, a grating allows the men to watch the play and sparking of the brushes. A tachmeter, or speed indicator, is bolted to the floor in front of the driver, and is run by a small belt from the armature. Along each side of the engine are run the long steel tubes of compressed air (charged at the generating station), for working the Westinghouse brake. The brake has the small valve handle to one side, and also an ordinary handle in case of need. Resistances are ranged along the other side and covered in; and two substantial switches, surmounted by an ammeter, are just to the driver's hand. One of these reverses the field magnets, and the other regulates the resistances. The locomotive is covered in in front, and the driver watches for the signals through the broad glass window. The word is given, he turns the switch, the engine moves slowly out, a shower of little red-hot sparks come from the conductor, and the engine moves off and dashes into darkness. The driver keeps one eye on the ammeter, with an occasional glance at the speed indicator, and the other on the blackness before him. The engine plunges forward, its lamps illuminating the white-bricked tunnel, sometimes down a slight incline, and a slight (perhaps fancied) additional chillness gives us the idea we are passing under the Thames rolling above, then round a slight curve and an upward tendency, and the glimmer of a green light is seen. Its gets nearer, we pass it, and the driver throws over the switch handle all the way round, and puts his hand to the brake valve. The red lamp in the station can now be seen, draws nearer, and the engine draws into the station, slowing up to the puff of the Westinghouse brake, and draws up easily just before the red lamp at the platform. The time from station to station is about three or four minutes, and the whole distance from the Monument to Stockwell takes just about a quarter of an hour. At present the trains will run every five minutes; if necessary hereafter a three minute service will be put on.

The Generating Station.

At Stockwell there is another handsome station in red brick and stone, surmounted with a dome, and furnished with lift as are the others. The generating station is some two or three minutes' walk across the road. In this station the three large vertical engines were at work driving the generating dynamos. Two of these were working at full speed, and the other is kept at slow speed, in case of a change over being necessary. The engines, as we have before stated, are of 400 h.p. They have 14ft. flywheels, driving the huge Mather and Platt dynamos, beside which a man looks small, by means of 18in. leather belting passing under jockey pulleys. At one end are the three horizontal air compressor engines, only working occasionally. At the other end is the switchboard, massively arranged. The conductors from the two dynamos are brought to this switchboard and connected in parallel, and from this feed on to the main conductor.

The conductor is in one continuous length, and is supplied with current at four distinct places by a system of feeders, as in an electric light system. These feeders are each controlled by a main switch, and the current to each passes through an ammeter registering up to 500 amperes. The switches are of the double-bladed knife pattern. Each switch is arranged with two fuses, so that if one should go, which may occasionally occur in starting with too sudden a rush of current, the switch can be switched over and another fuse be brought into use. There are thus four switches controlling the four feeder circuits. The return is made by the rails.

The current varies continually from 0 up to 500 amperes. On the occasion we inspected the ammeters they stood at 140, 160, 130, and 30 amperes—a total of 460 amperes. The average current per train is just about 50 amperes, varying from 0 on a decline up to 200 at start. The pressure is 500 volts. No difficulty is found with the wearing away of the conductor. Very few difficulties or accidents seem to have been encountered other than occasional going of a fuse in starting, with the exception that in the first place the original locomotive was found too light, and those in use at present are some two tons heavier, to provide sufficient friction for drawing the train at the requisite speed—25 miles an hour.

The boilers are situated below the ground level to give dry steam. There are six of these—Lancashire type—four of which are in use while the others are being cleaned, or kept banked up. The boilers are fitted with an automatic coal feeder, the patent of Messrs. T. and T. Vicars, of Liverpool and London, which seems to act admirably, and gives little trouble.

A number of well-known electrical and mechanical engineers, and other professional and business men, have visited the City and South of London Railway, and it must be acknowledged that the engineers have attacked this new and important problem in a direct and simple manner, which gives every promise and proof of a most successful undertaking. This line is, in reality, the first electric "railway" that has yet been built. It runs under stringent conditions of working such as will have to be accepted by engineers in operating present or prospective railways by electric traction, and we cannot be too proud that this important advance has been first successfully undertaken and accomplished—as so many other undertakings have been—in England and by English engineers.

NOTES ON THE CHEMISTRY OF SECONDARY CELLS.*

BY PROF. W. E. AYRTON, VICE-PRESIDENT; C. G. LAMB, B.SC., AND E. W. SMITH, ASSOCIATES.

(*Continued from page 482.*)

It will be seen that during the charging the variation in the hardness of the plugs is far greater at the top than at the bottom of the plates, and consistently with this fact Mr. Robertson's analyses show that, on the whole, the rate of chemical action at the top of the plates is greater than at the bottom. The difference in the hardness, however, is far more marked than the difference in the chemical action. For example, while the plugs at the top of the positive plates are, during the earlier part of the charging, much harder than those at the bottom, no such striking difference is observable in the percentage of lead peroxide contained by these plugs. The cause of this we are examining experimentally at the present time.

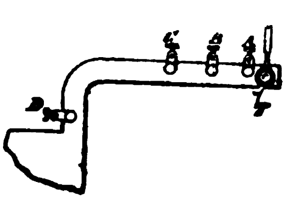

FIG. 7.

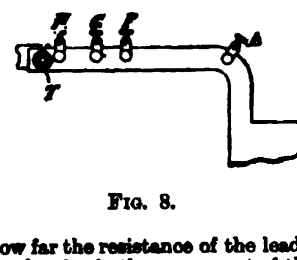

FIG. 8.

In order to see how far the resistance of the lead grid would tend to make the current density in the upper part of the liquid less than in the lower, as well as for the purpose of seeing how large a fraction of the whole resistance of the accumulators was due to the lead lugs and to the connections between the successive pairs of lugs, the following tests were made by three of the students, Messrs. Hobson, Lee, and Montealegre:

Parts of the lead lugs of some of the accumulators were scraped, and on these clean spots binding screws, which had been themselves filed bright, were tightly screwed. The accumulators were allowed to send measured currents, the values of which are given in the following tables, and the P.D. between the pairs of binding screws was carefully measured with a sensitive reflecting voltmeter. The resistance of the lugs between the pairs of binding screws is then obtained by dividing the P.D. by the current.

Fig.	Position of binding screws.	State of nut and screw T.	Length of lug in inches.	Current in amperes.	P.D. in volts.	Resistance in ohms.
7	A and D	—	—	8	0·00187	0·000230
	A and C	—	3·25	8	0·00117	0·000150
	A and B	—	1·5	8	0·00060	0·000079
	T and A	Dirty	Wire pressed on at T.	8	0·00038	0·000047
		Clean		8	0·00028	0·000035
		Dirty	Wire screwed on at T.	8	0·00028	0·000035
		Clean		8	0·00025	0·000031
8	E and H	—	6·5	8	0·00219	0·000270
	F and H	—	4·0	8	0·00128	0·000160
	G and H	—	1·5	8	0·00049	0·000060
	T and H	Dirty ...	—	8	0·00021	0·000030
		Clean ...	—	8	0·00021	0·000030
9	K and L	Dirty ...	—	8	0·00522	0·000650
	T and O	Dirty ...	—	8	0·00063	0·000080
		Clean ...	—	8	0·00057	0·000070
	K and L	Very dirty	13	5	0·00500	0·001000
	T and O	Very dirty	-	3	0·00524	0·001750
		Clean ...	—	10	0·00044	0·000044

From this it appears that the resistance per inch of the lug alone is about 0·000043 ohm; and that the resistance at the contact of two lugs, which were tightly screwed together when quite clean, but which have become very dirty from the acid spray falling on them, may be as high as 0·001 ohm, or 30 times the resistance of an inch of the lug itself. The resistance between T and O, Fig. 9, being greater than between K and L, when T was very dirty, is probably explained by the fact that when the wire was screwed under T to test the resistance between T and O, Fig. 9, it was screwed against an exceptionally dirty bit of the lug.

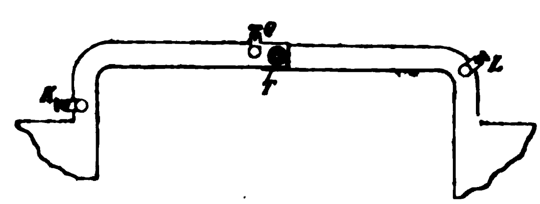

FIG. 9.

As we have shown in the Edinburgh paper, the mean resistance from positive lug to negative lug of one of these accumulators complete is about 0·004 ohm when the contacts between the lugs and the testing wires are made quite clean. Hence it appears that about one-seventh of the whole mean resistance of such an accumulator is caused by the resistance of the lead lugs themselves; and that the resistance of such accumulators as we have been experimenting with can, when joined up in series, be increased by 25 per cent. if the contacts be allowed to become dirty by the acid spray falling on them, even although they remain all tightly screwed up.

Since these tests were made we have had all the accumulators disconnected, the contacts carefully cleaned and tightly screwed up, and the nuts and screws then coated with hot paraffin wax.

The coarsely divided paraffined cork which is sold by Messrs. Drake and Gorham for floating on the tops of accumulators to filter the hydrogen gas from sulphuric acid spray, was most successful in stopping the acid fumes from escaping into the room when we first obtained it. As, however, the cork became thoroughly wetted with the liquid, its filtering property was much diminished. It appears to us that there still remains the need for a really good spray-arrester.

IV.—ANALYSIS OF PLUGS.

The following is the report of the analyses of the plugs removed at different stages of the charging and discharging, which Mr. Robertson has been so kind as to prepare for us:

Report by G. H. Robertson on Analyses made in the Chemical Department of the Central Institution of Plugs from an E.P.S. Cell.—October 16, 1890.

Preparation of the samples for analysis:

The positive samples were taken separately, washed on to filters, and thoroughly freed from acid. In every case the samples from the bottom were harder to wash than the others, and the residues were dried for some hours at about 120deg. C.

The samples were now ground up fine in an agate mortar, and the splinters of wood and glass removed as far as possible. The approximate weights for analysis were now taken and redried on watch glasses at about 140deg. C.

* Paper read before the Institution of Electrical Engineers.

At first the substance for analysis was dissolved in a porcelain dish, and the insoluble residue of sulphate was filtered off, with the intention of determining the amount of sulphate by the ammonium acetate method; but owing to the small amount of material available, and the error introduced by the solubility of lead sulphate in the nitric acid used to dissolve the sample, the attempt to determine both the peroxide and the sulphate was abandoned, and the samples were used to determine the peroxide only as accurately as possible. This course was justified by the fact that very careful qualitative experiments showed that nothing but peroxide and sulphate was present in the plugs.

The method employed to determine the peroxide was the ammonium oxalate and permanganate method described in Sutton's "Volumetric Analysis," as in previous analyses it had been found very sensitive; and the solutions were checked about every two days against pure lead peroxide, and each day the solutions were run against each other, but they were not found to alter practically in the time they lasted. The first lot of ammonium oxalate was standardised against permanganate which had been very accurately standardised against iron, and by the nitrometer method.

Using this solution "pure" lead peroxide, as purchased, and which afforded a slight white residue like silica, contained 97·3 per cent. as the mean of a large number of analyses made with different weights; and any subsequent solution which gave the percentage between 97·2 and 97·5, inclusive, was taken as correct.

It will be noticed that D and A' gave practically the same percentage as the sample of pure lead peroxide.

The residues from the samples containing the highest percentage of peroxide of lead were white, those from the samples containing the smaller percentage were brownish-white; and it was noticed that if the larger grains were crushed under the end of a glass rod they had a dark centre of peroxide, which at once dissolved, leaving a slight yellowish-white insoluble ring. By grinding the sample very fine in the mortar, so as to break up the capsules of sulphate more thoroughly, the residue was got lighter in colour; and using a flask to boil the substance in, the residue became perfectly white; but this yellowish-brown tinge to the sulphate does not seem to be due to any appreciable quantity of undissolved peroxide, as practically identical percentages were obtained with pure white and yellowish residues. Dark residues gave low results.

In the case of the very hard plugs, there was some error from the glass and wood, which could not be picked out altogether, though the samples were picked over very carefully (*cf.* D', E').

In the case of the negative plates, the sulphate was in such a loose and powdery condition that it fell off and adhered to the insides of the bottles used for receiving the plugs in, and it was quite impossible to obtain representative samples for quantitative analysis; so qualitative tests had to be made, which, in the case of charge, showed nothing but sulphate of lead and lead, the sulphate decreasing during charge until at D there was practically nothing but pure lead.

During discharge the sulphate increased; at C' there was a doubtful indication of peroxide of lead, and at D' and E' there was decided evidence of peroxide. After a few days the plugs were white all over, and there was no difference in appearance between the front and back. The water had no acid reaction.

Lead Peroxide Formed on the Positive Plates during Charge.

—	Percentage of PbO_2.	Mean.		Mean increase in percentage PbO_2 and time interval.	Total hours charge.	P.D. in volts just — Before break'g circuit.	P.D. in volts just — After closing circuit.	Specific gravity of liquid.
					H. M.			
A	Top 30·6 31·0 32·7	31·43	34·5*		0 37	2·134	2·122	1·178
	Middle 35·23 35·34	35·28						
	Bottom 36·5 37·3 36·6	36·80						
				H M 41·0* 9 11				
B	Top 77·0	77·00	75·5		9 48	2·2	2·186	1·198
	Middle 76·1 76·8	76·45						
	Bottom 73·2 73·3	73·25						
				8·8 1 49				
C	Top 88·0	88·00	84·3		11 37	2·234	2·186	1·201
	Middle 85·15 84·72	84·93						
	Bottom 79·8 80·3	80·05						
				10·8 2 50				
D	Top 96·3 96·8	96·5	95·1		14 27	2·4	—	1·206
	Middle 94·1 93·42	93·76						
	Bottom 95·00 95·11	95·05						

* Only the surface of the positive plugs was removed in the first attempt, A.

Lead Peroxide Reduced on the Positive Plates During Discharge.

—	Percentage of PbO_2.	Mean.		Mean increase in percentage PbO_2, and time interval.	Total hours discharge.	P.D. in volts just — Before break'g circuit.	P.D. in volts just — After closing circuit.	Specific gravity of liquid.
					H. M.			
A'	Top 96·7 97·0	96·85	94·9		0 25	1·998	2·002	1·205
	Middle 94·88 94·37	94·62						
	Bottom 93·4 93·1	93·25						
				H M 31·7 7 27				
B'	Top 67·5 67·06 67·0	67·2	63·2		7 52	1·956	1·958	1·189
	Middle 64·82 64·25	64·53						
	Bottom 57·9 57·7	57·8						
				15·3 4 16				
C'	Top 49·0 48·8 48·8 48·3	48·7	47·9		12 8	1·850	1·902	1·180
	Middle 49·92 50·5 50·2	50·45						
	Bottom 44·07 44·90	44·48						
				6·5 2 29				
D'	Top 41·8 44·01 43·9	43·2	41·4		14 37	0·6	1·9	1·175
	Middle 42·70 42·92	42·81						
	Bottom 37·9 38·6	38·25						
				5·4 3 26				
E'	Mixed 36·6 36·7 34·8	36·00			18 3	Zero E.M.F. indefinite on remaking circuit.		1·172

(*To be continued.*)

NOTES ON ECONOMY IN CONDUCTORS.

ABSTRACT OF DISCUSSION ON MR. KILGOUR'S PAPER.

After a few words of compliment upon the merit of the paper from the President of the Old Students' Association (**Mr. W. B. Esson**),

Prof. Perry, in opening the discussion, said that Mr. Kilgour's paper was one to be studied. It was the type of paper the Old Students' Association should have, and if they had many such their meetings might well rival those of the Institution of Electrial Engineers. At the institution they often had intensely practical papers by practical men who were generally scared at the slightest approach to mathematics; and they had also, on the other hand, some extremely learned papers. But they never seemed to get quite that sort of paper—one which really aimed at applying the scientific papers to work and making them practically useful. The tables therein given would be most useful, enabling engineers to refer instead of having to calculate each time. He did not think that Sir William Thomson's formula had ever been put into such a practical form before. The price of the Board of Trade unit, he thought, was taken too high, if inserted in the formula at the price to consumer. That at present was too much to take, but it was being reduced, and everyone hoped it would be much less in the future. Mr. Kilgour had taken the excellent practical case of the transmission of 100 h.p. a distance of five miles. It so happened that a very similar case had just come before himself, that he (Prof. Perry) and his brother were working out. They paid a stated charge for the use of water power, and he was astonished to find how little the actual cost came out. His brother had said that it had not sufficiently struck electrical engineers as yet that the cost of a Board of Trade unit in the future would be a very small sum—that was, when they could charge for the production alone, and not, as they now too often had to do, for mistakes as well. He would like to see more made of the case of "variable but uniform" circuits, and hoped Mr. Kilgour would be able to develop that point into another article. As to the paper read by himself and Prof. Ayrton, he hardly thought that anybody really appreciated or used it. He had tried to convince Prof. Forbes that he was wrong in thinking the transmission of power to considerable distances would be used in very few cases. He hoped and expected that it would be taken up in many cases, and that then engineers would settle down into taking those formulæ of the current density to be employed. He was interested to find at the time of the experiments in long-distance transmission of

Marcel Deprez that the current density employed satisfied fairly well the Ayrton and Perry formula. He could not help wishing that the paper had been elaborated a little more—it deserved elaborating. He would like to see other formulæ taken up in the same way. The case of telpher lines was an important one, long lines giving out power for trams every eighth of a mile or so; and a number of other interesting problems which should be equally worked out. One suggestion he would make was that it would have been handier if in the calculation the variable had been t, instead of the variable being L and N. He could only again express his feeling that it was an exceedingly valuable paper, and if they could only continue to have three such papers a year it would be astonishing how the association would grow in importance.

Mr. Raworth had to congratulate Mr. Kilgour upon his very excellent paper. He and Mr. Kilgour spent a good deal of time together, and he thought he saw the origin of the practical nature of his (Mr. Kilgour's) work. The calculation of the mere section of copper that was required was useless, because it did not take into consideration the make of the cable, and other matters that made the question far more complicated. Mr. Kilgour had been brought face to face with this problem, had tackled it, and arrived at results which would make it much easier to calculate the cables necessary for their contracts. Mr. Kilgour had now become a man of affairs and responsibility, and it was at great cost to himself that he worked out these results into the paper which would be so important to such of them who were engaged in business. One point to be remarked upon was that in the consideration of the n wire system, Mr. Kilgour had to start with the assumption that the current did not vary between the consumers or batches of lamps in the different sides of the system. That was a point on which we could not be at all sure. To be certain, the three, four or five wire system would have to be carried bodily into the houses, and designers of central stations could never go to that extreme. They had, therefore, to be content in making the section of the return wire in a three-wire system equal to half that of the main leads. When the cost of production per unit by steam or by water power was spoken about, there were two very different elements in the calculation. With steam, whatever number of units were produced extra, a proportionate amount of coal and oil had to be burnt or used. With water it was totally different; they had to deal simply with the wear and tear of machinery, but not with the varying amount of water used. Water did not cost anything from the point of view of consumption. There were two methods of paying for water power. They might either buy their water rights for a lump sum down, or pay a certain fixed annual rental, but in either case the amount of water used up did not affect the price of consumption. Another point was that in the calculation of overhead wires, depreciation should not figure to anything like the same amount as in underground mains. The amount of depreciation in such cases should be extremely small, because it was not to be expected that copper itself would go out of fashion, and it would always be able to be realised at the full value of old metal. Therefore, in places outside the influence of the Board of Trade, they could deal with overhead copper wires without having to allow any very wide margin for depreciation.

Mr. Geipel bore witness to the probable usefulness of the paper to electrical engineers in everyday practice. He thought the calculation of cost of mains should take into consideration the time conductors must be laid underground in many streets before the consumers make use of them. It was often found necessary to lay down mains which would not be used in the full capacity for some time to come, say five or even 10 years. He did not know whether Mr. Kilgour would include the system intended at St. Pancras, where continuous-current transformers were to be used in the category of lighting on the series system, inasmuch as he stated that no practical use of the series system for general station lighting has been made. He (Mr. Geipel) had worked out a table of electric conductors, which appeared some six years ago, in which the cost of insulation and of fixing are taken into account by expressing these factors as a percentage on the cost of the conductor, and uniting this with Sir W. Thomson's formula; the percentage being, of course, generally greater on small than on large conductors, and varying with the nature of the insulation, system of laying, etc. He had found this a simple and convenient method of calculation, though, of course, it would not be so accurate as the formula expounded by Mr. Kilgour.

Mr. Reckenzaun considered this contribution to practical mathematics one of the finest they had had, and one the association ought to be proud of. There was one thing he was not clear about, that was, it appeared as if Mr. Kilgour had treated all conductors either as laid on the surface of the road or as run overhead, and they all knew that often the cost of laying exceeded that of the main itself. Then again, he believed it to be proved that it was virtually impossible to transmit power for more than five miles underground at the maximum price of 8d. of the Board of Trade unit. Mr. Raworth seemed to state that steam would cost more than water, but it was evident that water power was not a very cheap power if they had to lay down a plant of turbine or waterwheel, and if used for only four or five hours a day for lighting. Water power only became economical when used constantly. Then storage batteries, charged during the whole 24 hours, would be economical, even taking the largest cost of depreciation or maintenance of cells into consideration.

Mr. Snell was sorry the paper was not in his hands a few days before, as it was impossible to go into calculations of the kind given without consideration, especially as the symbols and formulæ were different from those he was in the habit of using. If he had known the gist of the paper beforehand, he would have brought his own curves and figures to compare with those given by Mr. Kilgour. These, however, he hoped to publish shortly, and there would be a further opportunity of comparison. The question was complicated somewhat by the best pressure to be chosen. That would often depend upon circumstances outside that of cost of mains. For instance, in collieries they had been limited to 500 to 600 volts as their working pressure, as it was found impossible, owing to damp, to depend upon the insulation for higher pressures. He would take an opportunity to apply the equations to those installations his company had already carried out, and see how the calculations given agreed with what had been actually done. In a case of transmission of energy from water power which had been carried out very successfully by his company a short while ago in Bohemia, for hauling, pumping, and winding, as far as he could remember the quantities obtaining very closely approximated to Mr. Kilgour's figures.

Mr. W. B. Esson, the president, said that, though one of the speakers had mentioned that the cost of laying the conductors was not included in Mr. Kilgour's figures, he presumed that in a calculation relating to actual work to be carried out the author would be careful that this item, often a very important one, was not omitted. There seemed to be some misapprehension possible respecting Mr. Raworth's remark regarding the cost of water power. The fact was, that the charge made as a water-right was not of the nature of a cost which increased proportionally to the power used. It was a fixed charge, which had to be paid whether little or much of the power available was utilised. But its amount, though generally small, had, of course, to be considered with reference to the energy utilised in the course of the year. Prof. Perry had doubts as to whether many people had understood the significance of the paper he had read in conjunction with Prof. Ayrton on "Economy in Electrical Conductors" in 1886. He could not answer for others, but speaking for himself he (Mr. Esson) had regarded that paper as a very valuable one and most interesting to those who had to deal with problems involving the electrical transmission of power, inasmuch as for the first time it clearly specified the limits to the application of Sir William Thomson's well-known law. He had appreciated and utilised that paper, having based his working calculations upon the formulæ and reasoning it contained. As regards the particular problem of transmitting a certain amount of power over a given distance, the difference of potentials at the dynamo being fixed, he found a graphic method of utilising the formulæ of Profs. Ayrton and Perry of great value. Graphic treatment, of course, always appealed to engineers. He was anxious, however, to convince Prof. Perry that his valuable paper had not remained without appreciation, and he had no doubt the paper they had heard to-night would also form a valuable contribution to the literature which dealt with transmission of power problems. He would now ask Mr. Kilgour to reply to the various criticisms and remarks which had been made.

Mr. Kilgour, in reply, said, with reference to Prof. Perry's remarks, that he had at first intended to include some other problems, but had found it impossible through want of sufficient time to construct the necessary curves and tables. The telpherage problem, for instance, would have required an entirely fresh series of curves. He was indebted to Prof. Perry for his remarks as to the desirability of substituting another variable for t, as in the first problem dealt with. With reference to Mr. Raworth's remark on the three, four, and n wire systems, he thought it would not be difficult to assign an approximate value to m, but for this the character of the load diagrams of the different sections must be known previously. It was desirable to so adjust the loads in the different sections that the value of m should be as small as possible. To do this properly, it was essential that a careful canvass should be made of the district under consideration. The balancing of circuits should be done on the mains. He agreed with Mr. Raworth that it was at present improbable that the three or four-wire system would be introduced into houses, but he might mention that a specification had recently been sent out by a town in Germany in which it was enacted that all houses, factories, etc., should be wired on the three-wire system, so that the balance is maintained independently of adjustment between the mains. With reference to Mr. Raworth's remark, there was no doubt the depreciation taken was too large in the example given. He had not realised in making the calculations given in the paper that for bare overhead wires the proportion for depreciation might be taken at so much less. For insulated wires the insulation costs by far the greater part, and is often four, five, or even six times the cost of the bare copper, and in these cases a high rate of depreciation must be allowed for. In answer to Mr. Geipel's question as to the consideration of the time the mains were laid before being used, he did not think this was so important as might appear. The Westminster Supply Company, who were laying their mains on the three-wire system, made provision for easy adjustment by drawing in one strip of copper over the other as the demand increased and a greater thickness of copper became necessary. With regard to cost of laying, this consisted mostly in the construction of the conduit, which had to be constructed in any case, and the size of the conduit in any case would hardly be altered, even if the size of the cable were altered. He might refer to the question of the voltage used, and would say that one consideration to be taken into account in the employment of high voltages was the decreased efficiency of the dynamo, which would tend to the use of the moderate rates of high voltage. Thus, a dynamo supplying current at 2,000 volts was less efficient than a dynamo of 500 volts, and, again, a dynamo of 10,000 volts was less efficient than a 2,000-volt dynamo.

A vote of thanks to Mr. Kilgour for his paper terminated the proceedings.

THE

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TELEPHONY.

"There is a good deal of human natur in man," said Artemus Ward, and so the telephone companies will find; for under former management a more conceited, autocratic, stand-offish body it was as difficult to find as is the proverbial needle in the rick of hay. From the first promotion of telephony in this country till the beginning of the end, when the time of those managers was come, the users of telephones in London had no resource but to grin and bear his troubles. Complaints were pooh-poohed. Suggestions were met with bland smiles and incredulous stares; sometimes with a sneering query as to what the person making the suggestion knew about it. Outside London could be found managers who knew their business and studied their customers. The time has now come when the muddle-headed policy that actuated for many years the powers that ruled in London, will be severely tried. In our opinion the only part of the telephonic apparatus that formed a valid patent was the receiver, and Bell's patent for that has now lapsed. The mere fact that certain troubles were found when experimenting, could give no prior claim whatever to the grand discovery and completed work of Hughes. The general public as a rule are slow to recognise the worth of the men who serve them best, and too ready to estimate at their own amount the value of the men who clamour loudest and boast the most. Prof. Hughes made telephony practicable. Without his researches it was a lame horse—pretty for the laboratory, but of no earthly use elsewhere. The same may be said of Hughes's microphone without Bell's receiver. The two combined give almost a perfect system, and either alone is of little use without the other. For years telephonic monopolists have been reaping the pecuniary reward that Hughes declined, and taking the scientific credit that by rights was his. A free gift to the world was made subservient to the avarice of company-mongers, and a long purse secured a legal monopoly for the combination of transmitter and receiver. If those who had thus secured the monopoly had recognised the claims of civilised humanity, something might be said for them, but they did not. The price they have seem fit to charge for the use of apparatus badly put up and badly maintained has been exorbitant, and their terms almost an outrage upon business principles. To-day in the metropolis of the world there is one telephone, where, under a liberal management, there might be a thousand; there is one friend to those who have controlled the system, and a hundred dissatisfied users. The proper time to open a crusade against the present managers has, perhaps, not come; they have a few months more wherein to propitiate their customers and their would-be customers, and it must be admitted to

their credit that more has been done in their short time of office in this direction than was done in the whole reign of the preceding *regime*.

THE SOCIETY OF ARTS.

It is customary in some quarters to undervalue the work of the Society of Arts, but it is very probable, if the truth could be known, that it has done excellent work in educating the public to a juster comprehension of many advances in science and in practice. With regard to electrical matters the society has, for many years past, taken opportunities to bring before its members and others the position of affairs. On Wednesday last, pursuing this policy, Mr. Bailey read a paper at the ordinary meeting on the electric light in London. As will be seen, he brings the information at the command of the general public up to date. From the point of view of those engaged in the industry, however, the work of the society as shown in the Cantor Lectures will be most appreciated. Last session Prof. Thompson gave a most admirable series of lectures, which are now published in pamphlet form, and this session Mr. Kapp is to give lectures upon a subject in which he is *facile princeps*. Altogether, then, too much praise can hardly be given to a society which shows so just an appreciation of the position of electrical engineering, and which endeavours to further the cause by arranging for such valuable papers. If we might re-echo a suggestion often heard, it would be to urge upon the society the desirability of publishing the various Cantor Lectures as early as possible after their delivery.

ELECTRIC CONSTRUCTION CORPORATION.

Elsewhere will be found a full report of this company's meeting, the balance-sheet having been given in a previous issue. We do not profess to understand the figures in the balance-sheet that refer to the formation of subsidiary companies, and strongly recommend the attention of all interested to the remarks of the auditors. The shareholders are, or should be, mostly concerned with the results of the legitimate trading business, and here, as we have all along expected, the management has obtained results which on the whole must be pronounced satisfactory. The sales and work done amount to nearly a quarter of a million sterling, and a fair profit on this sum would suffice to pay a fair dividend upon a capital which we imagine suffered severely from moneys paid for promotion. A 10 per cent. net profit on the sales and work would just pay a 5 per cent. dividend upon the total capital. With regard to subsidiary companies, no doubt the rule is for the parent company to reap all the benefit, and the subsidiary company to reap all the loss. The parent company takes cash and shares. A part of these probably go to the promoting wire-pullers; but if the parent company gets any cash, it is a tangible asset, though the shares turn out valueless. We incline to the opinion that shares in subsidiary companies should not appear as tangible assets till such companies have actually paid dividends. A thousand shares in a company just floated are not usually realisable securities; they may be speculative tokens, that is all. Criticism against company promotion was heard at the meeting, and will no doubt have its effect. Meanwhile, there is plenty of room to increase the sales account from a quarter to half a million, and by so doing the shareholders will receive a larger dividend, and one earned in a manner no one can carp at as unsatisfactory.

THE LONDON ELECTRIC.

Messrs. Mappin Bros. write to the *Times* concerning the unfortunate position of the supply by this company. It is useless to attempt to hide the gravity of two breakdowns, and the more so because the electrical engineer knows that the misfortune has been caused by circumstances which absolutely have no bearing on the value of the system adopted. The users of the electric energy supplied by this company cannot be expected to make allowances for a transition period, but engineers will understand that the tentative and temporary arrangements made to tide over a time of change are far more liable to go wrong than the permanent arrangements. There is no doubt the company has had to contend with great difficulties, and had only to get safely through the troubles of change of station to put them into a position to really and truly test the system adopted. Messrs. Mappin quite correctly point out that there has been no reserve. There could not well be a reserve to temporary arrangements, but the permanent arrangements contemplate such reserve and such a system that the supply could hardly be completely cut off. We trust that engineers will be more long-suffering than those who at this moment are depending on the light but cannot get it, and will reserve judgment upon the whole system till such time as the system has been really tried.

CORRESPONDENCE.

ELECTRIC CRANES.

To the Editor of the Electrical Engineer.

SIR,—In your issue of 28th ult. appears a description of certain electric cranes. It would be of interest to know definitely of what form these are—whether overhead travelling, fixed, or portable. I notice the engineer makes a merit of what I and others who have made a study of the subject consider to be a great disadvantage—viz., the reversing of the motor to lower the load.

This reversing motion is, under any circumstances, a bad feature, and the gearing of the motor direct to toothed wheels can only result in the eventual destruction of the

armatures. The arrangement, no doubt, greatly simplifies the difficulties in the way of the application of electricity to cranes, but the effect will be to retard the progress of the improved motive power.

I have studied carefully all the latest and best American practice, and am myself building overhead cranes for the same power, and am strongly impressed with the fact that the motor should be run continuously, as far as possible, and, in any case, in one direction.

Mr. Sandwell is stated to be able to supply a two-ton crane, with motor and dynamo, for £100. This I fail to understand, if a proper sized motor be applied. If the load is to be lifted at usual rate, at least 7 h.p. will be required from the motor, and say 8 from the dynamo. Assuming the crane to be even a simple fixed wharf pattern, this brings the proper cost to a greater figure.

It is only right the public should not be misled on these points. Nothing can be gained by misunderstanding the features of electrical gearing of cranes, and the merits of handiness, quietude, and cleanliness are quite sufficient to procure its adoption, without injuring its prospects by doubtful applications to cheap work.

I regret to say that among electricians great ignorance prevails on the duties of hoisting machinery, and *vice versâ* among crane builders.

I fear the last transformation of the cranes you describe may prove less satisfactory than "seems to be expected," and will explain why.

If the power used for these cranes is, as given, 6 h.p., and they are "of more or less modern type," then there is not quite current enough to work one crane at usual speed. The power for the 12-ton derrick alone should be nearly double this to work properly.

It is not safe to assume, as has been done here, and to my knowledge elsewhere, that only one or at most two cranes will ever be at work lifting at one given period. If the cranes are in regular and rapid work, two-thirds of the total power is the proper figure.

There is nothing to be gained to the cause we have at heart by disparaging unduly the opposing force, steam.

Here a figure is given of £5 for fuel alone. I assume this is for the cranes now fitted with electric gear, and is excessive.

I have a two-ton steam crane on the River Thames, which is in constant work unloading mud barges, 45 to 50 full lifts of 35ft. per hour, which is not costing more than 6s. per day for fuel and labour, in this case being driven by a boy. There are scores of steam cranes doing heavy work here, costing no more than 9s. to 10s. per day, including man's labour.

As a sample of the inaccuracies common among statements on this subject, I may say I have seen an offer of a 1½-ton electrical wharf crane to make 30 lifts per minute. This may have been intended for "per hour," if so, it was equally wrong the other way, and in any case such inaccuracy on a new application of this interesting motive force is deeply to be regretted.

The whole question requires the most careful study from two points of view, that of the motor and that of the crane; and loose work at this early period will only have the result of deterring the public from the use of the electric crane.—Yours, etc., REGINALD BOLTON.

110, Leadenhall-street, E.C.

COST OF PRODUCING ELECTRICAL ENERGY.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—In your issue of Dec. 5th a letter appears from Mr. Charles H. Yeaman containing certain statements which, in the interest of the electrical industry, should be discussed.

Mr. Yeaman says, "It is an open secret nowadays that the cost of *producing* electrical energy runs somewhat about the equivalent of gas at 4s. to 4s. 3d. per 1,000 cubic feet."

During the last few months I have obtained statements from several large users of the electric light amongst the mill owners of Lancashire, showing the exact cost to them over various periods of time of their installations, with the result that after allowing amply for depreciation and interest on capital, the average cost of the light comes out at less than gas at 2s. 6d. per 1,000 cubic feet. A typical statement of this kind drawn up by the engineer to Messrs. Horrocks, Crewdson, and Co., the large mill owners, of Bolton, referring to an installation which has been under my own observation, appeared in the *Electrical Review* of Sept. 19, 1890; a copy of this I enclose.

It appears that Mr. Yeaman is basing his statement either on the results obtained in small private houses or other installations where necessarily the expenses are heavy, or on central stations which have not reached anything near their full capacity, and consequently are not running economically.

In comparing the cost of gas with electricity many fall into the error of taking five cubic feet of gas as equal to 16 c.p. Although this would be true if only standard London argand burners were used, as a matter of fact, these burners are not usually found convenient, and from those generally in use not one-half this efficiency is obtainable.

Referring to the life of incandescent lamps, Mr. Yeaman states "It has been found on English central station circuits that 500 to 600 hours is the most that can be reckoned upon where anything like an attempt is made to incandesce the lamps to give 16 c.p. at about 3·5 watts per c.p."

If this is the case (it is not with the only central station of which I have personal experience) it speaks very badly either for the careful running of the stations, for the system they are employing, or for the proportioning of their mains, as we find from a large experience in the lamp trade in this district that 1,200 hours is nearer the actual life of the lamps when running at full candle-power.—Yours, etc. W. P. JAMES FAWCUS,

Managing Director Manchester Edison-Swan Company.

Manchester, Dec. 9, 1890.

[ENCLOSURE.]

The Relative Cost of Gas and Electricity in Cotton Mills.

When it is attempted to draw comparisons between gas and electricity and their relative cost, it is not unusual to estimate the former by simply referring to the actual cost of the gas consumed as registered by the meter, whilst the cost of an electric light is obtained after every possible charge has been put down to its account. Such a result not unfrequently places the electric light at a serious disadvantage from the economical point of view.

But an estimate of this character is far too one-sided to give a true statement of the case. Those who are interested in the electrical industry do not object in the least to have the electric light properly debited with all the incidental and necessary items, but they do naturally object that, on the gas side, all the incidental items—save that of actual consumption—should be omitted. Neither is it fair altogether to omit from these calculations the relative benefits or otherwise derived from the use of the two illuminants.

As we have remarked, an electric light installation is debited with all its charges to the capital account, and in its maintenance not only is the depreciation of the plant considered, but every item due to repairs, wages, etc., is fully considered and provided for.

On the gas side, however, no such items are usually taken into account; but, dealing with the gas question in a large mill or manufactory, there are a number of expenses necessarily entailed, which should certainly be taken into account when a perfectly true and reliable comparison is desired. For instance, the installation of a gas plant of 1,000 or more lights into a large mill entails the expenditure of a considerable amount of capital, although it is known that a gas plant can be put in at the present time for a very small sum.

There are, however, many mills where the capital expended upon the gas installation has cost 20s. per light, whilst at the present time they can be installed for as low as 5s. or 6s. per jet. Still, this requires some capital, and, necessarily, should be subject to some charge for depreciation. The lighting up of a large mill, and the extinguishing of these lights, requires a considerable amount of labour and time. The value of wages taken up per annum in this alone is a serious item, but it does not count. It will be found that where there are a large number of

lights in use there is almost always a "gasman" employed in looking after the fittings, and keeping everything in proper repair; but his wages are not counted, nor are the various items which usually come under the head of repairs, for it is impossible to conceive that gas-pipes and fixtures are not out of order. Where the relative charges are properly considered, a more reliable estimate can therefore be obtained. But there are circumstances which prevent such a comparison from being made. This is owing to the fact that it is very rare for the cost of the maintenance of an electric light installation to be kept. We are aware, however, of several cases where this has been done, and we have the following statement presented to us for publication, which gives the information in a comparative form, prepared by the proprietors of some very large mills in the neighbourhood of Manchester. These results give the relative cost of gas and electricity for a period of six years, taken from the actual working experiences of one of the company's mills at Mosesgate, near Bolton. The statement is given exactly as handed to us:

HORROCKS, CREWDSON, AND CO., LIMITED, BOLTON.

Gas v. Electricity at Mosesgate Six Years to 31st December, 1889.

826 gas lights, cost of piping, meter, etc.	£215	2	2
Depreciation at 5 per cent. per annum, six years = £73. 12s. 11d., or per annum	12	5	6
Average gas account per annum	217	11	3
Total ... 826/	£229	16	9
Cost of gas per light per annum	£0	5	6¾
Electric installation (263 lamps) cost, including gearing, belting, etc.	£410	17	9
Depreciation at 7½ per cent. per annum, six years	153	10	1
Renewal of lamps, repairs, etc.	101	11	4
(Power, estimated at 30 i.h.p., at £5=£150.)			
Depreciation on £150 for six years at 5 per cent. per annum	39	14	4
Coal at 3·7lb. per i.h.p. per hour (275 hours per annum) for six years at 6s. per ton	22	2	0
6/	£316	17	9
Cost per annum ... 263/	52	16	3½
Cost per lamp per annum	0	4	0¼

Cost per light per annum—gas, 5s. 6¾d.; electricity, 4s. 0¼d. Gas costs 38·34 per cent. more per light, and (as one electric light displaced two gas lights in weaving-shed) gas costs 176·68 per cent. more per loom.

It will be observed that in the foregoing statement the gas account is simply debited with the average gas consumption and depreciation charge of 5 per cent. upon the original cost, nothing being allowed for repairs and such other charges as we have previously mentioned.

The account for the electric installation of 263 lights includes dynamo and everything that is necessary to a complete plant. The work in this case was satisfactorily done by the Manchester Edison-Swan Company, Limited, and it is gratifying to notice here that throughout the six years the working has been of a satisfactory character. The charge for depreciation is 7½ per cent., or one-half more than in the case of gas. The power of the steam engine is estimated at 30 i.h.p., that being the proportion of driving the dynamo. Tests subsequently made showed that the actual i.h.p. utilised was only 27 h.p., and at this figure the coal consumption has been calculated. The item for repairs, etc., includes the cost of oil and sundries, besides lamp renewals. It will therefore be seen that full charges has been debited to the electric light account. It may probably be remarked that no charge has been made on account of wages, but as the engineer in charge of the engines has done this small amount of work as part of his ordinary duty, no charge has been made, for no extra expense has been incurred. Under these circumstances the electric light shows a very distinct economy over gas, and it must be acknowledged that, in the case of a weaving-shed, the result is very remarkable. The present is a case where the mill engines have had their surplus power utilised in favour of the electric light installation, a case by no means unusual, and one which would undoubtedly be more frequently adopted if mill owners were more alive to this fact. In a very large number of instances the power required for the electric light has been in excess of that which could possibly be obtained from the mill engine, and an independent engine has been provided; and in other instances it has been considered advisable to have the power for the electric light quite independent. In these circumstances, again, an economy in the use of the electric light has been proved, and in a succeeding number we propose to give some details of the cost of working, with the additional charge of independent engines.

ELECTROLYTIC BLEACHING.

Mr. Andreoli writes, and to a certain extent justly, complaining of our terminating this discussion without allowing him a reply to Mr. Watt. Mr. Andreoli contends that Mr. Watt has not proved his case, and that "in spite of his long letter, Mr. Watt did not prove that his brother's patent was not posterior to those mentioned" by Mr. Andreoli. He contends also that the main facts he put forward are unanswered, and it is an error to say that since 1851 all who have worked in this direction are copying Mr. Watt.

No amount of discussion in technical papers will convince these antagonists, that is simply the reason why we cannot fill up our columns with such a discussion. Those who have patents will swear the patents are valid; those who want to use the process will try to use it in spite of current patents. Result, lawsuits and legal decisions. Nothing else will be accepted as final.—[ED. *E. E.*]

ELECTRIC LIGHTING PROGRESS IN LONDON.*

BY F. BAILEY, A.M.I.C.E.

The last paper on electric lighting read before the society was by Mr. R. E. B. Crompton, in 1888, when he placed before you some of the difficulties and obstacles which were retarding the progress of electric lighting. The rapid progress made within the last 18 months will, however, show that these difficulties have, to a great extent, been removed by a number of supply companies having obtained parliamentary powers to lay mains within certain specified areas into which London has been divided. I propose, therefore, to place before you, in general terms the work done and in progress by the various companies, as the time at my disposal will not permit me to give minute details of generating stations and systems.

Although the development of electric lighting has been so rapid within the last 10 years, it must not be forgotten that the arc light was shown at the Royal Institution in 1809, and remained a scientific curiosity until 1848, when Staite gave a public exhibition of his arc lamp from the portico of the National Gallery in Trafalgar-square. The *Illustrated London News* of that time gives a drawing of the scene, with the following remarks: "The electric light possesses no novelty. Year after year it has been exhibited at every course of philosophical lectures since the time of Sir Humphrey Davy, and, therefore, really its practicability forms the whole subject for consideration." The electrical energy for this light was obtained from a primary battery; and it is probable that the practicability of this method of obtaining light will continue to remain a subject for remote consideration. At this time, the seed sown by Faraday's discovery, in 1831, of electromagnetic induction, had fallen on fruitful soil; and the wonderful dynamos of to-day form a suitable monument to his genius.

You will see, therefore, that electric lighting commenced its career in London, and London ought, therefore, to show the greatest progress. The incandescent lamp, in some form or another, is mentioned almost yearly from 1836 onwards, and I propose to at once jump to the period when Swan in England and Edison in America brought out the present form of lamp.

Through the kindness of Mr. J. W. Swan I have the honour to show you the first lamp he made. It is to be hoped that this lamp will eventually come under the care of one of our great museums, in order that future ages may recognise the genius of Mr. Swan.

I have also to thank Mr. Sydney Morse for the loan of another valuable historical lamp, this being the first lamp constructed by Edison.

Time does not permit me to trace the history of the incandescent lamp, or the extraordinary development of its manufacture. Nothing could have been done practically without the mercury pump, and we ought, therefore, to place the inventor, Dr. Sprengel, in a high position on our records of pioneers.

Turning to the record of general distribution of the electric light in London, you all know that practically nothing was done under the Act of 1882, but private enterprise provided fields for encouraging the efforts of the electrical engineer, and foremost amongst these must be mentioned the Grosvenor Gallery station, which did such good service in making the capabilities of the light known, and in proving the absolute necessity that

* Paper read before the Society of Arts on Wednesday, Dec. 10.

existed for it; for however defective the supply may have been towards the close of the existence of the station (owing to the plant being overloaded), we owe a debt of gratitude to Lord Crawford for his energetic support to this enterprise, and to those who worked so hard to bring it to perfection. Mr. Ferranti, and those who had worked with him at the Grosvenor, laid the foundation-stone of a satisfactory transformer system, and as they had no parliamentary powers to lay down underground mains, overhead lines were run in all directions. The perfection to which they brought the details of overhead construction is so fully proved by the absence of accidents that it is much to be regretted that the overhead conductors in the United States were allowed to have been put up with no regard to common-sense or safety.

It is frequently stated that the Electric Lighting Act of 1882 did much towards stifling inordinate speculation, but in attempting to make people wise by this Act of Parliament, a very serious check was placed upon the development of electrical progress.

The enormous strides which have been made under the more encouraging Electric Lighting Act of 1888 will convince everyone that it was urgently required, and electrical engineers fully realise what they owe to Sir Frederick Bramwell for his share in framing this Act. One of the consequences of this Act was a deluge of applications for provisional orders. A court of enquiry was therefore ordered by the Board of Trade, who appointed Major Marindin as their inspector for this purpose.

If you carefully read the 18 days' evidence given, you will probably be convinced that every system was the best. The enquiry lasted several days, and resulted in the granting of provisional orders, confirmed by Parliament in August, 1889, to the companies mentioned in the summary at the end of paper, which also includes other information.

I must here gratefully acknowledge the very cordial assistance which the engineers of the various companies have given me.

We will now very briefly go round the stations of the companies, commencing with

The Kensington and Knightsbridge Electric Light Company.

This company commenced work under the name of the Kensington Court Electric Light Company in the autumn of 1886, and under Mr. Crompton's able guidance made such rapid progress that they commenced to supply current in January, 1887, using underground mains and running their plant in a temporary building. The Board of Trade license under which the work commenced, being incorporated in the company's provisional order of 1889, which authorises them to supply a portion of the parish of Kensington, St. Mary Abbott, and the detached portion of the parish of St. Margaret, Westminster.

The direct current is employed in conjunction with "Howell" secondary batteries, the pressure being 200 volts on the three-system, with 100 volts in the houses.

The batteries are charged at any convenient time when the engines have power to spare, and not only act as a sponge, which can be squeezed when the engine plant requires assistance, but also acts as regulators, as well as maintaining the supply during the hours of minimum demand. The satisfactory use of secondary batteries in this manner has attained its present development mainly through the indefatigable labours of Mr. J. C. Howell.

Two generating stations are erected, one at Kensington-court and the other at Chapel-place, Knightsbridge, the plant consisting of Babcock and Wilcox boilers and exhaust steam feed water heaters, Willans compound engines, combined direct with Crompton dynamos and Howell batteries in both stations. There is also a battery station situated near the centre of the Kensington district at Queen's-terrace-mews, where two large Howell batteries are placed. In all cases ample space is provided for the future extension of the plant when required. Arrangements are provided on the Kensington-court station switchboards to enable any dynamo to be used for charging the distant battery station, to which a pair of charging mains are laid. Mr. Crompton also designed for this company a system of mains of considerable novelty, and which was severely criticised at the time, but has since proved most satisfactory.

Culverts constructed with concrete or brickwork are laid under the pavements, and bare copper conductors, supported at intervals by glass insulators, are placed in these culverts. The conductors are composed of copper strips 1in. by ⅛in., laid one over the other, so as to make up the total section required. In cases where there is no room under the pavement in which to build up the culvert, wrought-iron gas tubing is used, and cables insulated with thick vulcanised rubber are drawn through and connected to the bare conductors. Numerous service-boxes are fixed in the pavements to enable houses to be connected without opening the ground. Four and a-half miles of pipes with cables have been laid. The general route of the mains is indicated on the map.

On December 1 lamps were connected to an equivalent of 24,850 32-watt lamps, and Mr. H. W. Miller, the company's engineer, to whom I am indebted for these particulars, informs me that the lamp supply, or maximum number of lamps in use at one moment, is between 30-40 per cent. of the lamp connection.

The House-to-House Electric Light Supply Company.

This company, as you see on the map, covers a large area, which consists of two detached districts, practically North Kensington and West Brompton. The generating station is situated off the Richmond-road, West Brompton, and contains space for a very large plant.

The Lowrie-Hall alternating-current transformer system is adopted, with 2,000 volts on the mains. Four principal mains at present carry the current from the station, the transformers being connected to these mains where required. Cast-iron pipes are laid to form a conduit into which vulcanised india-rubber Silvertown cables are drawn; suitable manholes, covers, and junction-boxes being provided.

At present the demand for light is supplied from a plant consisting of three Babcock and Wilcox boilers, working at 150lb. per square inch. Three Fowler compound horizontal engines, each of 200 i.h.p. Three Lowrie-Hall alternators, each of 100 units, 2,000 volts. Three Elwell-Parker exciters, each of three units.

The engines work at a speed of 88 revolutions per minute, each engine driving one alternator by seven cotton ropes, the exciter for each alternator being driven by cotton ropes from the alternator pulley.

The Lowrie-Hall pressure regulator and recording instruments are also used. Mr. Hall, the company's manager, has kindly given me this information, and states that on their lamp connections, equivalent to 12,898 lamps of 8 c.p., the maximum lamp supply is equivalent to 5,430 lamps of 8 c.p.—say, 42 per cent.

(To be continued.)

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

Lecture III.

(Continued from page 508.)

Position and Form of Armature.

In one of Du Moncel's papers on electromagnets you will also find a discussion on armatures, and the best forms for working in different positions. Amongst other things in Du Moncel you will find this paradox; that whereas using a horseshoe magnet with flat poles and a flat piece of soft iron for armature, it sticks on far tighter when put on edgeways; on the other hand, if you are going to work at a distance, across air, the attraction is far greater when it is set flatways. I explained the advantage of narrowing the surfaces by contact by the law of traction, B^2 coming in. Why should we have for an action at a distance the greater advantage from placing the armature flatway to the poles? It is simply that you thereby reduce the reluctance offered by the air gap to the flow of the magnetic lines. Du Moncel also tried the difference between round armatures and flat ones, and found that a cylindrical armature was only attracted about half as strongly as a prismatic armature, having the same surface when at the same distance. Let us examine this fact in the light of the magnetic circuit. The poles are flat. You have at a certain distance away a round armature; there is a certain distance between its nearest side and the polar surfaces. If you have at the same distance away a flat armature having the same surface, and, therefore, about the same tendency to leak, why do you get a greater pull in this case than in that? I think it is clear that if they are at the same distance away, giving the same range of motion, there is a greater magnetic reluctance in the case of the round armature, although there is the same periphery, because though the nearest part of the surface is at the prescribed distance, the rest of the under surface is farther away; so that the gain found in substituting an armature with a flat surface is a gain resulting from the diminution in the resistance offered by the air gap.

Pole-pieces on Horseshoe Magnets.

Another of Du Moncel's researches relates to the effect of polar projections or shoes—movable pole-pieces, if you like—upon a horseshoe electromagnet. The core of this magnet was of round iron four centimetres in diameter, and the parallel limbs were 10 centimetres long and six centimetres apart. The shoes consisted of two flat pieces of iron slotted out at one end, so that they could be slid along over the poles and brought nearer together. The attraction exerted on a flat armature across air gaps two millimetres thick was measured by counterpoising. Exciting this electromagnet with a certain battery, it was found that the attraction was greatest when the shoes were pushed to about 15 millimetres, or about one-quarter of the interpolar distance, apart. The numbers were as follows:

Distance between shoes. Millimetres.	Attraction, in grammes.
2	900
10	1,012
15	1,025
25	965
40	890
60	550

* Cantor lectures, delivered before the Society of Arts.

With a stronger battery the magnet without shoes had an attraction of 885 grammes, but with the shoes 15 millimetres apart, 1,195 grammes. When one pole only was employed the attraction, which was 88 grammes without a shoe, was diminished by adding a shoe to 39 grammes.

CONTRAST BETWEEN ELECTROMAGNETS AND PERMANENT MAGNETS.

Now I want particularly to ask you to guard against the idea that all these results obtained from electromagnets are equally applicable to permanent magnets of steel; they are not, for this simple reason. With an electromagnet, when you put the armature near, and make the magnetic circuit better, you not only get more magnetic lines going through that armature, but you get more magnetic lines going through the whole of the iron. You get more magnetic lines round the bend when you put an armature on to the poles, because you have a magnetic circuit of less reluctance, with the same external magnetising power in the coils acting around it. Therefore, in that case, you will have a greater magnetic flux all the way round. The data obtained with the electromagnet, Fig. 42, with the exploring coil, *c*, on the bend of the core, when the armature was in contact, and when it was removed, are most significant. When the armature was present it multiplied the total magnetic flow tenfold for weak currents, and nearly threefold for strong currents. But with a steel horseshoe magnetised once for all, the magnetic lines that flow around the bend of the steel are a fixed quantity, and however much you diminish the reluctance of the magnetic circuit you do not create or evoke any more. When the armature is away the magnetic lines arch across, not at the ends of the horseshoe only, but from its flanks; the whole of the magnetic lines leaking somehow across the space. When you have put the armature on, these lines, instead of arching out into space as freely as they did, pass for the most part along the steel limbs and through the iron armature.

FIG. 52.—Experiment with Permanent Magnet.

You may still have a considerable amount of leakage, but you have not made one line more go through the bent part. You have absolutely the same number going through the bend with the armature off as with the armature on. You do not add to the total number by reducing the magnetic reluctance, because you are not working under the influence of a constantly impressed magnetising force. By putting the armature on to a steel horseshoe magnet you only *collect* the magnetic lines, you do not *multiply* them. This is not a matter of conjecture. A group of my students have been making experiments in the following way. They took this large steel horseshoe magnet, Fig. 52, the length of which from end to end through the steel is 42½in. A light narrow frame was constructed so that it could be slipped on over the magnet, and on it were wound 30 turns of fine wire, to serve as an exploring coil. The ends of this coil were carried to a distant part of the laboratory, and connected to a sensitive ballistic galvanometer. The mode of experimenting is as follows: The coil is slipped on over the magnet, or over its armature, to any desired position. The armature of the magnet is placed gently upon the poles, and time enough is allowed to elapse for the galvanometer needle to settle to zero. The armature is then suddenly detached. The first swing measures the change, due to removing the armature, in the number of magnetic lines that pass through the coil in the particular position.

I will roughly repeat the experiment before you: the spot of light on the screen is reflected from my galvanometer at the far end of the table. I place the exploring coil just over the pole, and slide on the armature; then close the galvanometer circuit. Now I detach the armature, and you observe the large swing. I shift the exploring coil, right up to the bend; replace the armature; wait until the spot of light is brought to rest at the zero of the scale. Now, on detaching the armature, the movement of the spot of light is quite imperceptible. In our careful laboratory experiments, the effect was noticed inch by inch all along the magnet. The effect when the exploring coil was over the bend was not as great as 1-3,000th part of the effect when the coil was hard up to the pole. We are therefore justified in saying that the number of magnetic lines in a permanently magnetised steel horseshoe magnet is not altered by the presence or absence of the armature.

You will have noticed that I always put on the armature gently. It does not do to slam on the armature; every time you do so, you knock some of the so-called permanent magnetism out of it. But you may pull off the armature as suddenly as you like. It does the magnet good rather than harm. There is a popular superstition that you ought never to pull off the keeper of a magnet suddenly. On investigation, it is found that the facts are just the other way. You may pull off the keeper as suddenly as you like; but you should never slam it on.

From these experimental results I pass to the special design of electromagnets for special purposes.

ELECTROMAGNETS FOR MAXIMUM TRACTION.

These have already been dealt with in the preceding lecture; the characteristic feature of all the forms suitable for traction being the compact magnetic circuit.

Several times it has been proposed to increase the power of electromagnets by constructing them with intermediate masses of iron between the central core and the outside, between the layers of windings. All these constructions are founded on fallacies. Such iron is far better placed either right inside the coils or right outside them, so that it may properly constitute a part of the magnetic circuit. The constructions known as Camacho's and Cance's, and one patented by Mr. S. A. Varley in 1867, belonging to this delusive order of ideas, are now entirely obsolete.

Another construction which is periodically brought forward as a novelty is the use of iron windings of wire or strip in place of copper winding. The lower electric conductivity of iron, as compared with copper, makes such a construction wasteful of exciting power. To apply equal magnetising power by means of an iron coil implies the expenditure of about six times as many watts as need be expended if the coil is of copper.

ELECTROMAGNETS FOR MAXIMUM RANGE OF ATTRACTION.

We have already laid down the principle which will enable us to design electromagnets to act at a distance. We want our magnet to project, as it were, its force across the greatest length of air gap. Clearly, then, such a magnet must have a very large magnetising power, with many ampere-turns upon it, to be able to make the required number of magnetic lines pass across the air resistance. Also, it is clear that the poles must not be too close together for its work, otherwise the magnetic lines at one pole will be likely to curl round and take short cuts to the other pole. There must be a wider width between the poles than is desirable in electromagnets for traction.

ELECTROMAGNETS OF MINIMUM WEIGHT.

In designing an apparatus to put on board a boat or a balloon, where weight is a consideration of primary importance, there is again a difference. There are three things that come into play—iron, copper, and electric current. The current weighs nothing, therefore if you are going to sacrifice everything else to weight, you may have comparatively little iron, but you must have enough copper to be able to carry the electric current; and under such circumstances you must not mind heating your wires nearly red hot to pass the biggest possible current. Provide as little copper as you conveniently can, sacrificing economy in that case to the attainment of your object; but, of course, you must use fireproof material—such as asbestos—for insulating, instead of cotton or silk.

A USEFUL GUIDING PRINCIPLE.

In all cases of design there is one leading principle which will be found of great assistance—namely, that a magnet always tends so to act as though it tried to diminish the length of its magnetic circuit. It tries to grow more compact. This is the reverse of that which holds good with an electric current. The electric circuit always tries to enlarge itself so as to enclose as much space as possible, but the magnetic circuit always tries to make itself as compact as possible. Armatures are drawn in as near as can be, to close up the magnetic circuit. Many two-pole electromagnets show a tendency to bend together when the current is turned on. One form in particular, which was devised by Ruhmkorff for the purpose of repeating Faraday's celebrated experiment on the magnetic rotation of polarised light, is liable to this defect. Indeed, this form of electromagnet is often designed very badly, the yoke being too thin, both mechanically and magnetically, for the purpose which it has to fulfil.

Here is a small electric bell, constructed by Wagener of Wiesbaden, the construction of which illustrates this principle. The electromagnet, a horseshoe, lies horizontally; its poles are provided with protruding curved pins of brass. Through the armature are drilled two holes, so that it can be hung upon the two brass pins; and when so hung up it touches the ends of the iron cores just at one edge, being held from more perfect contact by a spring. There is no complete gap, therefore, in the magnetic circuit. When the current comes and applies a magnetising power, it finds the magnetic circuit already complete in the sense that there are no absolute gaps. But the circuit can be bettered by tilting the armature to bring it flat against the polar ends, that being indeed the mode of motion. This is a most reliable and sensitive pattern of bell.

Electromagnetic Pop-gun.—Here is another curious illustration of the tendency to complete the magnetic circuit. Here is a tubular electromagnet, Fig. 53, consisting of a small bobbin, the core of which is an iron tube about 2in. long. There is nothing very unusual about it; it will stick on, as you see, to pieces of iron when the current is turned on. It clearly is an ordinary electromagnet in that respect. Now, suppose I take a little round rod of iron about an inch long, and put it into the end of the tube, what will happen when I turn on my current? In this apparatus as it stands the magnetic circuit consists of a short length of iron, and then all the rest is air. The magnetic circuit will try to complete itself, not by shortening the iron, but by lengthening it, by

pushing the piece of iron out so as to afford more surface for leakage.

That is exactly what happens; for, as you see, when I turn on the current the little piece of iron shoots out and drops down. You see that little piece of iron shoot out with considerable force. It becomes a sort of magnetic pop-gun. This is an experiment which

Fig. 53.—Electromagnetic Pop-gun.

has been twice discovered. I found it first described by Count du Moncel in the pages of *La Lumière Electrique*, under the name of the "pistolet électromagnétique"; and Mr. Shelford Bidwell invented it independently. I am indebted to him for the use of this apparatus. He gave an account of it to the Physical Society in 1885, but the reporter missed it I suppose, as there is no record in the society's *Proceedings*.

(*To be continued.*)

MULLINGAR DISTRICT LUNATIC ASYLUM.

[The list of tenders for this work was given in our last issue. In the hope that the full specification may prove useful to engineers having to specify similar work, we give it herewith.—Ed. *E. E.*]

SPECIFICATION FOR ELECTRIC LIGHT INSTALLATION.

1. Engine.—To be of the high-pressure, non-condensing type, working at 60lb. boiler pressure, and developing 70 indicated horse-power, fitted with specially heavy flywheel, to ensure steadiness in driving, and turned on face to receive driving belt; special electric light governor, with hand-regulating tackle, to adjust the speed without stopping the engine; sight-feed lubricating arrangement for bearings; all other necessary lubricators, drain-taps and stop-valve. Note.—The estimate is not to include the steam boilers, as the existing boilers are to be utilised.

2. Dynamo.—To be compound-wound and self-regulating, enabling any number of lamps to be turned off without the candle-power of the remainder varying, having output of 105 volts, and not less than 350 amperes; speed not to exceed 900 revolutions per minute; fitted with butt contact brushes, and brush-holders arranged with spring-forward thrust and hold-off catch. Commutator to be made up of copper bars insulated with mica. Terminal board, with brass terminals. Sight-feed lubricators for bearings, carrying rails, and screw-tightening gear to enable slack of belt to be taken up whilst running; machine to have an efficiency, or ratio of electrical work at terminals to net mechanical work taken up by armature spindle, of not less than 90 per cent. at full load, and able to sustain continuous runs of six hours without undue heating, or sparking at the brushes either from mechanical or electrical causes.

3. Belting.—To be of sufficient length to connect engine with dynamo, and to be double laid leather with patent fasteners for jointing.

4. Cables and Leading Wires.—To be of high conductivity, 96 per cent. of pure copper, and of section equal to not less than one square inch per thousand amperes, to be insulated in such a manner as to give an insulation resistance of not less than 400 megohms per statute mile, at 60deg. F.

5. Main Distribution Board.—To consist of substantial slate base polished on the front, on which is mounted the necessary brasswork, connected by large terminals on the reverse side to the mains, each circuit to be provided with a fuse and to be so arranged that any of eight circuits may be connected to one dynamo. One direct-reading voltmeter, to read up to 120 volts, fitted with switch; one ampere-meter, to read up to not less than 400 amperes, and arranged with short-circuiting plug; both instruments to be fitted on the distribution board. The whole to be arranged on iron carrying brackets and fitted to the wall in engine-house.

6. Circuits.—The lights to be divided up into eight circuits. Each of the three floors of the female wing to have its own individual circuit, and the male wing to be arranged in identically the same manner. The central position of the building, consisting of board-room, entrance, and reception-room, doctor's apartments, offices, and bedrooms, the whole spread over three floors, to be connected on to one circuit. The outside lighting to be connected up to the eighth circuit on the distribution board.

7. Cut-outs and Safety Fuses.—To be arranged at all branches, and should be of the double pole, main and branch type, mounted on porcelain base, and fitted with safety fuses, so proportioned as to melt with an excessive current of not more than 25 per cent. above that for which they are intended.

8. Position of the Wires.—All wires to be brought to the various positions as agreed upon between the contractors and the representatives of the Board.

9. Wood Casings.—All conductors to be enclosed in substantial casing of hard, dry, white wood, except in the offices and private rooms, when specially finished casing is necessary; the positives and negatives to be placed in separate grooves, and for small sizes to have a width of wood of not less than ⅜in. between them; for the larger sizes the separating space to be not less than 1¼in. On no account must the wires be run without casing, except for outside lighting.

10. Switches.—To be of the single-pole type, mounted on slate base, with fusible cut-out and brass covers, except when otherwise specified in the appendix, and to be so arranged that they can only be operated by means of detachable key, somewhat similar to those used for locking railway carriage doors. Switches must be identical in all respects, so that any one key may operate in all cases. This does not apply to the switches in the central portion—*i.e*, private apartments of the building; these may be of the ordinary type, with fixed operating handles.

11. Lamp Sockets.—To be of brass, fitted with or without shade carriers as may be required, with cord grip nozzles, terminals mounted on slate body, and to fit Edison-Swan brass collar lamps.

12. Incandescent Lamps.—Four hundred and twenty 16 nominal candle-power, 105-volt Edison-Swan lamps, with brass collars. Twenty lamps of 200 c.p., with special holders, shade carriers, shades not less than 15in. in diameter, and special ceiling roses with cut-outs.

13. Shades.—To be either enamelled iron, opal or fancy glass shades, as may be required; in cases where the latter are used, specially finished brass shade carriers of artistic design will be required.

14. Brackets.—To be either of the ordinary iron, straight polished brass, swan-necked polished brass, or special ornamental polished brass, as may be required in accordance with Appendix B.

15. Table Lamps.—With flexible cord to allow for movement will be required in accordance with Appendix B, and to consist of polished brass with heavy base, tripod shade carrier and shade, or ordinary workshop pattern with shade.

16. Chandeliers.—As specified in Appendix B.

17. Ceiling Roses.—To be of the ordinary porcelain type, with cut-out and screw cover, but in special cases to be of superior design, as specified in Appendix B.

18. Other Fittings.—As specified in Appendix B.

19. Erection.—The whole of the above material to be of the very best quality, and erected in the best manner, and according to the requirements of the Board, and set to work in accordance with the rules of the Phœnix Fire Office, as given in Appendix C. Provide in the estimate a sum of £25, to be expended at the discretion of the engineer upon foundations for engine and dynamo, and all the necessary steam and exhaust connections for engine.

20. Guarantee.—If, during the first six months after starting the light, any fault be discovered and which is proved to be due to inferior material or bad workmanship, it will have to be rectified free of charge.

21. Payments.—The contractor is to be paid as the work proceeds, on the written certificate of the engineer, in amounts as may be agreed upon, but in no case shall any such amount added to the amounts of the former certificates exceed nine-tenths of the value of work done up to the date of such certificate. The last instalment shall be payable at the end of the period of upholding, being the remaining 10 per cent. of the value of the whole work done. All payments should be made to the contractor on the authority of the engineer's certificate, and without the production of a certificate signed by the engineer, the contractor will not be entitled to any payment from the governors.

22. Certificate.—The certificate shall state the amount of money which the engineer considers should be paid to the contractor, and in arriving at this amount he shall have regard to the quantity of work executed in the several departments at the date of their examination, and the rate of progress of the works. No account shall be taken of materials laid upon the ground but not worked up. The amount stated in any certificate (save the final one) shall be merely approximate, and shall be without prejudice to either party's right. The certificates shall be signed by the engineer and handed to the contractor, who must deliver them to the resident medical superintendent. The contractor will be entitled to payment of the certificates within one fortnight after the first meeting of the governors next after he shall have lodged them with the resident medical superintendent as above. It is, however, to be clearly understood that the payment on account of any portion of the work does not adopt such work as finally completed, and all materials and workmanship which may prove unsuitable or turn out defective in the engineer's opinion, even after they have been paid for on account, shall be made good to the engineer's satisfaction, or removed as the case may require. Certified payments on account shall in no case alter or remove the contractor's liability in respect of the works. At the end of the period of upholding the engineer shall issue a final certificate stating that the works have been completed and upheld in accordance with the terms of the contract, and that the contractor is entitled to be paid the balance of money lying to his credit in the governors' hands. The engineer shall, however, as already stated, have full power to refuse a certificate, either intermediate

or final, in case that the progress of the works, the character of the workmanship, the quality of the materials, or any other matter is not in conformity with the drawings and specification.

23. Completion of the Works.—The whole of the works are to be completed in every respect and handed over under a certificate from the engineer for the use of the governors within the period of four months from the date of the contract agreement, but such handing over is not to relieve the contractor from his liability to uphold the works for six months after their completion under the provisions hereof. No extension of the above period of four months will be granted save in the event of extra work having been ordered.

24. Contract Agreement.—To give this specification legal effect a sealed agreement is to be entered into between the governors and the party whose tender shall have been accepted by the governors. This agreement shall be prepared by the governors' solicitor, at their cost, and will include the specification and the drawings and such legal covenants and other conditions as may be necessary, and in the case of any dispute as to what other conditions are necessary, the same shall be referred to the engineer, whose decision shall be final and binding on all parties. It is, however, to be clearly understood that the party selected by the resolution of the governors shall not be considered the contractor until the contract agreement has been executed, and he shall have no claim against the governors in case the matter fall through before the execution of the agreement.

25. Damages Paid for Delay.—Should the contractor fail, either through default or neglect, in having the works completed and handed over to the governors within the period named above, he shall forfeit and pay to the governors as liquidated damages the sum of £10 weekly for each and every week that may elapse between the contract and actual date of completion, and the governors shall deduct the total amount of such liquidated damages out of any balance lying in their hands to the contractor's credit. In addition to the foregoing, should the works not be completed within the time specified, the engineer shall withhold all certificates for payments on account until the works are actually completed.

26. Upholding.—The contractor is to uphold the whole of the works of the contract for a period of six months after the date upon which they shall have been handed over to the governors under the engineer's certificate. All necessary repairs and reconstructions must be made from time to time as required, and all defective workmanship and materials which may be discovered must be removed and made good; all failures or other defects must be remedied and the portion of the works affected thereby must be made good and left in accordance with the specification. At the end of the period of upholding, should the engineer be satisfied with the condition of the works, the governors shall take them off the contractor's hands by a final certificate; should, however, the state of things not satisfy the engineer he shall refuse such final certificate, and shall have full power under this contract to withhold it until such time as the contractor shall have put the works into a condition satisfactory to the engineer. The contractor to break through all holes where necessary in the walls of the building and to make good on completion. The cutting of holes through the face-work or mouldings to be executed by a competent and careful stonecutter; the contractor to be responsible for any damage done, and will, if directed by the architect, be required to remove injured stones and replace with new stone of corresponding quality, and to be neatly finished. All flagging, tiling on concrete flooring to be made good with material of corresponding quality and pattern, and finished in the best manner possible. All plastering damaged or disturbed in any way will have to be hacked off and relathed with laths equal to existing ones, securely nailed, and plaster to be well mixed with clean hair. All ornamental glass or ordinary glazing broken will have to be renewed with glass of similar quality and pattern, and fixed in manner to correspond. The contractor to provide all necessary carpentry work and attendance upon the fitters, to cut through and make good all floors, joists, etc. All casings and sheeting round fittings and pipes to be left complete, and so arranged as to afford easy access to the fittings and pipes. All painting, distemper, colouring injured to be renovated and made good by experienced workmen, and finished in the best possible manner, to correspond in every way with the existing work. The entire building, at the completion, to be cleaned of all rubbish, dirt, old materials, and whatsoever may accumulate during the execution of the work, and given up in a clean and fit state.

APPENDIX A.

List of Lamps as shown on Plan.

Ground Floor.

	16 c.p. lamps.	200 c.p. lamps.		16 c.p. lamps.	200 c.p. lamps.
Over main entrance	—	1	Female wing	80	1
Hall	2	—	Male wing	79	1
Stairs	1	—	Epileptic ward A	5	1
M room	3	—	" " B	5	—
Board room	3	—	Attendants' dining-room	—	1
Corridor X	4	—	Kitchen	2	1
N room	1	—	Stairs	1	—
Store	2	—	Shoemakers	4	—
Keeper's room	2	—	Tailors	3	—
Office	2	—	Carpenters	4	—
Superintendent's office	2	—	Stables	4	—
O room	1	—	Harness-rooms	2	—
P corridor	1	—	Total	213	5

First Floor.

	16 c.p. lamps.	200 c.p. lamps.		16 c.p. lamps.	200 c.p. lamps.
Female wing	40	1	R.R.	2	—
Male wing	40	1	Larder and pantry	2	—
Doctor's study	4	—	Doctor's kitchen	3	—
Stairs	1	—	Scullery	1	—
Drawing-room	3	—	Sink	1	—
Dining-room	3	—	Servants' bedroom	1	—
Passage	4	—			
Corridor	3	—	Total	108	2

Second Floor.

	16 c.p. lamps.	200 c.p. lamps.		16 c.p. lamps.	200 c.p. lamps.
Female wing	38	1	V bedroom	1	—
Male wing	38	1	Corridor	2	—
Doctor's bedroom	2	—	W.C.	1	—
Stairs	1	—	Passage	2	—
T bedroom	2	—	Rooms in passage	6	—
U bedroom	2	—	Total	95	2

Outside Lightifig and Offices.

	16 c.p. lamps.	200 c.p. lamps.		16 c.p. lamps.	200 c.p. lamps.
Avenue	—	2	Engine-house	4	—
Lodge gates	—	1	Laundry	1	—
Around asylum	—	8	Washhouse	1	—
Lodge	6	—			
Boiler-house	2	—	Total	14	11

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	16 c.p. lamps.	200 c.p. lamps.
Outside lighting and offices	14	11
Ground floor	213	5
First floor	108	2
Second floor	95	2
Total	430	20

APPENDIX B.

General Arrangement of Lights.

1. Main Entrance.—One high c.p. lamp with holder and shade not less than 15in. diameter. Porcelain switch of artistic design, with cut-out and cover, to be erected in the entrance hall.

2. Hall.—Two pendants, each consisting of specially finished ceiling rose, cut-out and screw cover, flexible service cord, silk finished, lampholder with slate body, artistic shade carrier and fancy coloured glass shade, no switch.

3. Board-room.—One three-lighted chandelier, highly finished and of artistic design, ceiling rose, and switch, with cut-out and cover to match, all necessary shades or globes, lampholder, etc., complete.

4. Stairs.—One swan-necked polished brass bracket lamp complete, with fancy coloured glass shade and wall rosette, no switch, cut-out to be erected at branch from main.

5. M Room.—One three-light chandelier complete, and erected similar in all respects to the one in Board-room.

6. Corridor X.—Four pendants, similar in all respects to those in the hall. No switch.

7. N Room.—One swan-necked polished brass bracket complete, with fancy coloured glass shade, wall rosette, single-pole switch, mounted on slate base, with fuse and screw cover.

8. Store.—Two pendants, each consisting of porcelain ceiling-rose, with cut-out and cover, lampholder or slate base with shade carrier, cord grip nozzle, and opal glass shade. One switch similar to the one in N room.

9. Keeper's Room.—To be lighted in the same manner as store (No. 8).

10. Office.—Same as store No. 8, but each lamp to have its own switch.

11. Superintendent's Room.—Same as office (No. 10).

12. Waiting-room O.—To be lighted in the same manner as N room (No. 7).

13. Corridor P.—Pendant similar to those in store (No. 8), but no switch.

14. Stairs F.—Same as No. 4, but with opal glass shade.

15 Female Wing:

1. *Padded Cells.*—These lamps must be placed in fittings consisting of enamelled iron reflectors, glass fronts, brass guards, and to be fitted with lock and key. The whole arrangement to be fitted on the wall or ceiling as may be required. Switch must be erected outside the cell in the corridor, and should be arranged to operate by means of a detachable key as specified.

2. *Attendants' Room.*—To be lighted by pendants, each consisting of porcelain ceiling rose, cut-out and screw cover, flexible workshop cord, lampholder with shade carrier, opal shade and switch with ordinary operating handle.

3. *Store-rooms.*—Bracket lamps, ordinary 9in. iron type, with opal shade, switch, wall rosette, and cut-out at branching joints.

4. *Dormitories Nos.* 1, 2, *and* 3.—All pendants same as attendants' room (2), but with enamelled iron shades, and removable key, switch to each room.

5. *Corridor A.*—Pendants same as dormitories, but no switch.

6. *K.K.*—Brackets, ordinary 9in. iron type with enamelled iron shades, lampholders, and removable key switches.

7. *Workroom.*—One brass bracket (swan neck), two workshop table lamps, and three pendants, all arranged with enamelled iron shades, lampholders, porcelain ceiling roses, cut-out, and covers, one switch with removable key, tablelamps to have sufficient

length of flexible cord to allow movement of not less than 2ft. in any direction.

8. *Dayroom.*—To be lighted by one high candle-power lamp, fitted with holder, shade, ceiling rose, and switch with removable key.

9. *Corridor B.*—Same as A (No. 5).

10. *Corridor C.*—Same as A (No. 5).

11. *Cells in Corridor C.*—Same as padded cells.

12. *Matron's Office.*—Two pendants with opal shades, one switch, ceiling roses, etc.

13. *Corridor D.*—Same as (No. 5).

14. *Dormitory No.* 4.—Is arranged similar to cells in corridor C, (No. 11), but with three lamps in corridor, same as corridor A (No. 5).

15. *Room A.*—Pendant as before, with enamelled shade and guard for lamp, switch same as padded cells.

16. Stairs.—Same as No. 14.

17. Dayroom A.—Pendants same as dormitories 1, 2, and 3, one switch with removable key.

18. Male Wing.—To be lighted in identically the same manner as the female wing.

19. Epileptic Wards.—To be lighted with two lamps, same as padded cells, and three pendants similar to dormitories Nos. 1, 2, and 3, one switch with removable key to each ward.

20. Attendants' Dining Hall.—One lamp similar in all respects to dayroom (No. 17).

21. Kitchen.—Same as dining hall (No. 20), but with two extra iron bracket lamps, one on each side of fireplace, and one being arranged to allow lamp to be taken down to examine inside of oven.

22. Boiler-house.—Pendants similar to corridor A; no switch.

23. Engine-house.—Same as No. 22.

24. Laundry.—Iron wall bracket with enamel shade, and removable key switch.

25. Washhouse.—Same as No. 24.

26. Shoemakers' Shop.—Pendants same as No. 22; one switch with movable key.

27. Tailors.—Same as No. 26.

28. Carpenters.—Same as No. 26.

29 Harness-room.—Same as No. 26.

30. Stables.—Same as No. 26.

31. Attendant-room (above harness-room).—Same as No. 26.

32. Lodge.—Same as No. 26, but with opal shades, and ordinary switch to each lamp.

33. Outside Lighting.—To be lighted with high candle-power lamps, as in dayroom—present posts, etc., to be utilised; circuit to be bare copper wire, high conductivity, supported on insulators, and connected to the eighth connection block on switchboard; each lamp to have its own switch, similar to the one in dayroom; shades to be erected in four cases only, and four cast-iron brackets to be provided to carry lamps from corners of the building.

FIRST FLOOR.

34. Male and Female Wings.—To be lighted in the same manner as on the ground floor.

35. Doctor's Study.—To be lighted by three polished brass brackets of good design, fitted with coloured glass shades, and ordinary operating switch of artistic design, one polished brass table lamp with tripod shade, and switch combined.

36. Dining-room.—Three-light chandelier, polished brass, complete with coloured shade, etc., and switch.

36A. Stairs.—Same as No. 4.

37. Drawing-room.—Three brackets and switch, same as No. 36.

38. Passage.—Same as corridor (No. 6).

39. R. R.—Pendants same as store (No. 8).

40. Larder.—Bracket same as N room (No. 7), but with opal shade.

41. Pantry.—Same as No. 40.

42. Kitchen.—Same as No. 8, store.

43. Scullery and Sink.—Brackets, ordinary iron type, with one switch to the two, similar in all other respects to No. 40.

44. Servant's Bedroom.—Pendant similar to kitchen, with switch.

45. Back Passage.—Same as corridor A.

SECOND FLOOR.

46. Male and Female Wings.—Same as before.

47. Stairs.—Same as No. 36.

48. S Bedroom.—Two ordinary brackets, each with switch, opal shade, cut-out, etc.

49. T Bedroom.—Same as No. 48.

50. U Bedroom.—Pendant with switch, same as in No. 8, store.

51. V and W Water Closets. — Brackets same as N room (No. 7), but with opal shades.

52. Passage.—Same as No. 38.

53. Back.—Same as No. 45.

54. Bedroom.—Pendant, same as No. 50.

55. Four Rooms.—Pendant, same as No. 50, but only one switch.

In the private house apartments, switches with ordinary operating handles are necessary.

Note.—No. 1 estimate to include all the works in the foregoing specification and Appendices A and B.

APPENDIX C.

SUPPLEMENTAL SPECIFICATION OF WORKS TO BE DONE WHEN THE ACCUMULATORS ARE ADDED.

THE ENGINE.—Supplied in accordance with specification, to be arranged to drive a countershaft, from which the main dynamo, already specified, will be driven, and also the additional dynamo for charging the accumulators; dynamos to be arranged to work independently of each other, so that one machine may work while the other is not running.

DYNAMO.—To be shunt wound for charging accumulators, having an output of 130 volts 50 amperes, at a speed not exceeding 1,200 revolutions per minute, carrying rails and screw-tightening gear to enable slack of belt to be taken up whilst running. Commutators made up of copper bars insulated with mica, butt contact brushes and holders, with spring-forward and thrust and hold-off catch, sight-feed lubricators for bearings, capable of charging accumulators without undue heating or sparking either from electrical or mechanical causes.

ACCUMULATORS.—To be of the Electric Construction Corporation's make, 23L size, having all the latest improvements, and requiring a charging current not exceeding 46 amperes, capable of discharging up to 46 amperes of 10 hours, to be erected upon glass insulators in wooden trays. The number of accumulators cells required will be 54 (fifty-four).

SWITCHBOARD.—To be of the Electric Construction Corporation's regulation type, fitted with switches for turning on extra cells to compensate for fall in E.M.F. towards the end of discharge, main switch and fuse, volt and ammeters complete with arrangement for making direct connection between the cells and any or all of the eight circuits of the building.

AUTOMATIC SWITCH.—To cut out dynamo in the event of a fall in the E.M.F. through stoppage of the engine, etc.

VOLTMETER.—For testing the E.M.F. of each cell, and to be of the direct low reading type, with connecting pin for coupling to cells.

HAND LAMP.—Fitted with guard, reflector, bayonet, lampholder, lamp flexible wire, pin connection, and fuse complete for inspecting the cells.

GENERAL.—All necessary gearing, belting, cables, wires, hydrometers, spare parts, and other requisites for the satisfactory working of the above plant to be supplied.

ERECTION.—The whole of the above plant will require erection in the dynamo-house, excepting the cells, these being placed where most convenient, and as near to the engine-house as possible, and set to work to the satisfaction of the Board's engineers. All foundations, and other labour in erection, to be supplied by the electric light contractor.

GUARANTEE AND TERMS.—Same as general specification.

Note.—No. 2 estimate to embrace the works in the supplemental specification, Appendix C.

COMPANIES' MEETINGS.

ELECTRIC CONSTRUCTION CORPORATION.

The first ordinary meeting of the shareholders of this Company was held on Monday at the offices, Worcester House, Walbrook, E.C.; Sir Henry C. Mance, C.I.E., in the chair.

The notice convening the meeting and the Auditors' report were read by the **Secretary** (Mr. F. Walton):

AUDITORS' REPORT.

"To the Members of the Electric Construction Corporation, Limited: Gentlemen,—We have audited the acounts from the commencement of the Company—viz., 7th June 1889, up to 30th September, 1890—and have examined the profit and loss account and balance-sheet with the books, vouchers, and accounts. The sum of £121,963. 12s. 5d. on the credit side of the profit and loss account is represented to a great extent by shares which stand in the balance-sheet at par. It is impossible to say what is the exact amount that ought to be carried to capital account in respect of the cost of patents sold and depreciation caused by the licenses granted, but we think the round sum of £100,000 should be ample. In connection with these financial transactions there is a contingent liability for uncalled capital, about £90,000; but any payment in respect of this liability should increase the assets of the Corporation. We are informed by the managers of the works at Wolverhampton and Millwall that the plant and machinery have been fully kept out of revenue; but we think it advisable that a considerable sum should be placed as a reserve for depreciation, and beg to suggest that the Directors' recommendation of placing £15,000 as such reserve should be adopted. One of the subsidiary set of books do not balance by the sum of £1. 18s. 5d., and so much time has been occupied in endeavouring to find this difference that the completion of the audit has been delayed. We believe sufficient reserves have been made to meet any error affecting profit and loss account.

"BROADS, PATERSON, AND Co.,

"1, Walbrook, E.C., Nov. 24, 1890."

The **Chairman** then said: Gentlemen, I have now the pleasure of presenting to you the report and accounts of the Company for the period ending September 30 this year, I presume that, in accordance with the usual custom, you will prefer to take them as read ("Yes!") [The report and balance-sheet will be found in our issue for Nov. 28.] That being the case, I will proceed, without further delay, to go through the accounts, and just touch upon a few items that seem to me to require a little extra explanation. Now, commencing at once on the credit side of the profit and loss account, the first item is £4,061 on account of apportionment of profit. I may explain that this represents the amount which, after liberal deductions for depreciation, cost of experiments, etc., the Auditors certify as profit not belonging to capital. Although we took over the benefits of the working of the Elwell-Parker Company from September, 1888, we are not allowed to count towards revenue any profits that were made before the date of the incorporation of this Company. These profits therefore go to increase the capital value, and do not appear in our

profit and loss account. There is some little difficulty in apportioning the exact amount of the earnings for the period mentioned, but you may take it that it is roughly approximate. Probably it may have been put too low, but you will understand that if you have not these earnings set out as profits you have them in the increased value of the business which we acquired. It is simply a matter of account. The items, work, sales and expenses, speak for themselves. I have only to say that in working out for yourselves the net trading profits it will be fair to include a considerable portion of the item that follows of £14,000 charged against head office expenses. This should be deducted to arrive at the net trade results. I may also point out to you that these head office expenses are for a period of nearly 16 months, not 12 months. In connection with the item of interest on temporary loans it is desirable to mention that it was necessary to obtain these advances in order to complete our engagements with the vendors. A part of this item might, therefore, fairly have been charged to capital. We think, however, that it is of more importance to put the affairs of the Corporation on a sound financial basis than to present to you too glowing a balance-sheet, and the same principle has been applied here as in the item of preliminary expenses and the other expenses items—that is to say, the whole of the expenditure has been written off against the first year's working. Further, in regard to that item of other expenses you will, of course, easily understand that advertising must always be a serious cost, and if it is worth doing at all it ought to be done well. A considerable portion of that item, £3,948, is made up by the estimated cost of goods which were sent to the Edinburgh Exhibition, which is another form of advertisement. To be on the safe side, and bearing in mind the fact that returned goods are often very much depreciated in value, we have written off the entire cost of these goods, so that if anything is realised eventually from them it will come into the accounts as net profit. Then we have cash and shares, the item of £121,900.

When the Corporation took over the businesses that we have acquired there were foreign patents of undoubted but undeveloped value. The patent fees themselves were a heavy charge, while the income was nominal. These patent fees are included under the heading of head office expenses. The Directors have made it their business to realise these foreign patents by handing them over to a subsidiary company. To a great extent this item is represented by paper only—that is to say, so far as the purchase-money for patents is concerned, they having been paid for in shares. The result of the transfer has fairly justified the expectations of the Directors, for not only has a drain upon revenue been stayed, but the transfer of these foreign patents has resulted already in a satisfactory development of business in the countries concerned. Upon paper these transactions show an extremely satisfactory profit, but the shareholders will, I am sure, support the policy of the Directors in their decision not to apply any portion of the sales of patents to the credit of revenue until the present patent account is practically written off. While on the subject of patents I may mention that both at Millwall and Wolverhampton we are always experimenting in order to keep up with the business of the day, and it has sometimes happened that in working on one thing we discover others which are even of more value than the object originally sought for. When we took over the Elwell-Parker business, one of the patents, which was lying dormant at the time, was a method of obtaining phosphorus by the assistance of electricity from phosphate of aluminium. I regret that the gale of wind which we had in November damaged our buildings there, and therefore the experiment is not sufficiently far advanced to allow me to say anything certain to-day; but Mr. Parker and his co-inventor, Dr. Readman, are very sanguine—as inventors usually are—and they have every hope of bringing it to a successful issue. It may be in your minds that the aluminium process was entirely revolutionised by the application of electricity, and I see no reason why we should not be equally successful with phosphorus. Be that as it may, we have risked very little and we have gained most valuable experience with our electrical furnace, from which I believe that great discoveries with electricity will be made in the near future.

With this little digression we will go on with the balance-sheet, which I hope you will agree is a very good one, remembering that this is the first year's working, that we have had to get custom together, and that we have not had the benefit of our new works. I do not know there is much for comment, but I should like to have seen a much smaller item under the heading of calls in arrear. We all of us know, however, that in the City of London we have passed through a very critical and trying time, and no doubt many have found it very difficult to meet all the calls upon them. I trust that in next year's accounts this item will disappear altogether. The liability for trade accounts includes, I may tell you, a substantial sum for reserve, without there being any apparent probability of our being called upon to use it. The capital liability of £17,555 has been considerably reduced, in fact, almost paid off, since September; but there are still outstanding liabilities for the completion of our Bushbury works and other matters which are in course of adjustment and settlement. The loan on provisional debentures has also been materially reduced out of our current receipts. The item of contingent liabilities is one dealt with in the Auditors' report. Our contract for the equipment of the Rathbone-place and Manchester-square stations of the Metropolitan Electric Supply Company is now almost completed, although there is a responsibility attached to the running of the machinery which does not expire for some time. With regard to the liability on shares partly paid up, there is not much probability of the contingent liabilities for calls becoming actual liabilities to any great extent. The matter is practically in our own hands, and calls upon our resources of this nature would arise only in the event of such a development of business on the part of subsidiary companies as would be a matter of congratulation for all of us. As I have already mentioned, the item of preliminary expenses has been entirely written off, and will not appear again. Turning now to the credit side of the account, you will notice that the purchase-money of £397,300 has been reduced by the value of stock and book debts. This is a matter of bookkeeping only, and the items reappear below. But you will also observe that the purchase cost of our businesses has been reduced by the further item of £100,000 for licenses and patent sales, and this, you will agree with me, is not a mere matter of bookkeeping, but one of considerable satisfaction and congratulation. I hope this policy and our ability to continue it will appear in future accounts. Our capital expenditure since the acquisition of the businesses has been practically limited to the building of the new Bushbury works.

The cost of these works has been great—much greater than was originally contemplated, but we have felt ourselves bound to meet the requirements, and our action will, I am sure, be justified by the increased capacity which it gives us for carrying out work. I think this policy will commend itself to the shareholders—that, although it is very good to make profits by means of subsidiary companies, still we must bear in mind that we must look for future dividends to our manufacturing profits; and it is, therefore, our duty to put this Company in the foremost rank of manufacturing companies. That we have endeavoured to do. It is not enough, gentlemen, that we should have a character for turning out good work—that we have, but you must have a reputation for turning it out promptly, punctually, and with despatch. You must be able to turn out a large amount of work in a short time. We have had to refuse orders in the past year because we could not guarantee quick delivery. I hope that that will never occur again, and I believe that we have put at your disposal a factory which can be extended so as to meet all requirements that are likely to be made upon you in the future. I think when you see these works—and we had hoped to meet you there to-day—you will agree with us that your money has been very well spent. It is, in my opinion, the finest factory in the world. The freehold ground on which it stands is 21 acres in area. The works themselves occupy a space of over six acres. There is access to the London and North-Western Railway adjoining by means of a siding, and the canal is close to one end of the place. There is excellent water on the property, and every facility for extending the works, and I think we could, if we chose, dispose at a profit of any ground which we are not able to use for some years, or we might utilise such part of the property for the building of workmen's cottages. The item of book debts, amounting to £104,882, includes a claim upon the vendor for liabilities of the business purchased paid by the Corporation, amounting to £12,091 odd. You must not assume this to be a case of over-payment to the vendor. The amount which we paid to the vendor for the business was exactly the sum which we contracted to pay; but the conditions under which the vendor acquired the business of the Electrical Power Storage Company, and the conditions under which we acquired the business from the vendor, were a little different, and that led to this result, which is satisfactory to us if not to the vendor. The vendor purchased the business at a price sufficient to pay all liabilities and a certain sum to the shareholders, and the calculation was apparently based upon the accounts as they stood at the previous stocktaking. We purchased the property from the vendor at a fixed sum, free from liabilities. Now it happened that between the period of the stocktaking and the purchase there had been an augmentation of business, which is not always usual in the case of businesses handed over to companies; and the result was that the assets and the liabilities in respect to those assets were alike increased. Of course, we took over the assets in accordance with our contract, and it was the duty of the vendor to discharge all the liabilities. Having regard to the difficulties of such a course in a current business, provision was made in our contract that in the event of our discharging any of the liabilities, the vendor would recoup us the amount. Probably the vendor may have been surprised that the amount was so large, but the matter was gone into and equitably settled, and since the date of our report the claim has been settled. I do not think I have any further remarks to make abut the accounts.

Looking at the numerous applications which are being made all over the country for provisional orders, and the steady progress that has already been made by the different supply companies, I do not think we can have any doubt as to the future of the electric light. But great as the field is in this respect, I think it is likely to be eclipsed by the demand that will be made for electricity for other purposes. There are not wanting signs of activity in other branches where electric energy can be advantageously applied. In America the motor industry is even greater than that of electric light. The electric light is said to be a luxury, the time will come when it will be a necessity. But in the case of electric power we are not only better than anybody else, but we are cheaper. That is where I have great belief in the transmission of power by electricity. I went over a factory the other day, and the manager said to me, Every new shed I erect, every new machine I put down, I shall convey the power to it by electricity. At the Bushbury works we use electricity for the cranes, saws, lathes, and heavy machinery. There is one point on which we have been a little disappointed—that is in connection with train lighting. Now, with my failing sight, I speak feelingly as to train lighting. Anyone going by the five o'clock train from St. Pancras must be convinced at once of the beauty and superiority of this method of lighting the trains. In dealing with directors of railway companies, you are dealing with a very

conservative body of men, who are more likely to look at first cost than the convenience of their passengers; but I hope if any of you are shareholders in railway companies you will, at their next meeting, impress upon them the desirability of introducing this beautiful illuminant into their service. We have been more fortunate with traction. By the assistance of Mr. Smith—than whom, perhaps, there is no better authority in this kingdom—we have been able to introduce a series of electrical tramcars at Birmingham, where they are now working, and I believe, in a very satisfactory manner. I hope this is only one of a long series of similar installations all over the country. Seeing that we have these developments in electricity going on in every direction, and bearing in mind that we have important contracts ahead, and that we have incurred a large expenditure on these new works, we think the time has come when you should entrust us with more capital. We should have asked for this before, but the time has not been propitious, and, acting on the advice of our financial advisers, we have put it off. In order to enable us to secure the full advantage of what I hope will be a great boom in electric lighting and traction, we propose to issue £150,000 in 6 per cent. debentures. We have postponed this as long as possible, but we think we should now be neglecting your interests if we did not make the issue early next year at least. We assume that these debentures will be to a large extent taken up by the shareholders; and I can assure you the Directors will be quite prepared to take more than their share if necessary. There will, of course, be a public issue, in order to obtain a Stock Exchange quotation later on for them; but our own shareholders will receive the preference. (A Shareholder having apparently misunderstood the Chairman, he added)—You are all aware that we have a Stock Exchange quotation for our shares. That is all I have to say, and I now move the adoption of the report and accounts.

This was seconded by **Mr. J. S. Balfour, M.P.**, vice-chairman.

Mr. Mander said that he and his friends having a considerable interest in the Company, he was naturally anxious for its welfare. He was glad to be able to confirm a good deal that Sir Henry Mance had said about the works at Wolverhampton, as he (the speaker) lived there, and knew this Company and its predecessor. They certainly had down there one of the finest works in the country. It was very improbable that there were any other works so well carried out, and so amply provided with the means of completing orders. This was largely to be credited to the Directors and the works director, Mr. Parker. The latter had been known to him for many years, and in the opinion of the speaker and his friends, as well as of leading electricians, he was one of the most capable electricians in the country. He also knew him to be a man of the highest honour, and therefore he had ventured to send a notice to the Chairman that he would propose Mr. Parker as a director to occupy the position of Sir Douglas Fox, whose departure he greatly regretted. Mr. Parker's election would give satisfaction to many of the shareholders in the country, but they would leave it to the judgment of the Board. As regarded the general balance-sheet, he certainly found it very difficult as a young man, and one well experienced in his own business, but not in that of public companies, to offer any criticism upon it. They would, however, excuse him if he said that when he and his friends interested themselves in that Company, it was because they had the greatest possible faith in the future of electricity, and believed in a genuine manufacturing concern. What had cost them anxiety was that the Directors had thought wise to depart from this policy. It looked as if the Company were becoming a company-promoting company, as already three subsidiary concerns had appeared with large capitals. He would like to know what had been received in actual cost for the sales of patents, and how much in shares in these subsidiary companies. He would have thought it better to retain the rights of manufacture which they had such ample means of dealing with at Wolverhampton, where the works could not be fully occupied for years to come. Beyond that, he would like to ask as to the head office expenses. It seemed to him that these and the "other expenses," some £18,000, were very enormous. He was glad the item of £12,000 had been settled. He asked as to the rate paid for loans, because the item of nearly £5,000 (£4,837. 18s. 7d.) seemed to him extraordinary? Also, had the whole of the shares been paid in cash, or had some been paid in bills which had since been met? As a manufacturing concern he had the greatest belief in this Company, and he would venture to suggest that if the Directors confined themselves to that sphere there would be nothing but prosperity before them. But he regarded with infinite dislike the idea of being connected with a company that launched forth into the practice of company-mongering, which brought discredit to those connected with it.

Dr. Drysdale asked whether electricity was likely to be used in London on the tramways soon. Mr. Carpenter, who had been in America, had told him that in Boston and most other cities everything was done by electricity in the way of tramways, and he hoped the Company would procure the adoption of electric traction in the streets of London.

Mr. Hancock endorsed strongly the remarks made by Mr. Mander; he did not like the Company forming subsidiary ones and taking payment in shares. At the formation of that Company something like £360,000 was paid in cash, out of which something like £100,000 to £105,000 was left to work the business. He could quite understand that the Company required more money, if that £100,000 represented cash as working capital. With regard to the issue of the debentures, it was a serious question for shareholders that they should be issued at 6 per cent. He did not agree with the shares of the subsidiary companies having been taken as an asset at par, and would be far more satisfied if the Directors had placed a larger sum to reserve. It was a most serious question for them to consider that so large a portion of their hard cash stood in the shape of patents. Some of these had run for a considerable time, and others could not have many more years to run, and by the time these ran out they ought to have in reserve a fund that would redeem the amount. He made these remarks in no unfriendly spirit. He had subscribed largely to the Company; he had great faith in many of the Directors. There was no question, seeing how it was worked out, that they were too liberal in the amount they paid for the Company. At the same time, he had no doubt whatever that there was a future and a good and very profitable one before that Company, on this condition, that the Directors of the Company stuck to it as a manufacturing company, and that only; that they should not form any more subsidiary companies, and take shares in these companies in return for the hard sovereigns they (the shareholders) paid to them. Both electric lighting, traction, and accumulators were businesses only in their infancy, and might easily multiply fivefold in four or five years. He was a large shareholder, and intended to stick to his shares for some time to come, because he believed that although they had not received that reward which they were entitled to expect from the prospectus, yet that the reason given by the Directors was a sufficient one—viz., that they had been devoting their time to building up works to obtain an increased out-turn.

Mr. Judd congratulated the Directors upon the result of 16 months' trading and work in the comparatively new field. It was felt by many that the experimental stages of the applications of electricity to various purposes had still more difficulties to go through than it had suffered from already. Despite this notion, they had reached their present point, which was surely matter for congratulation. In reference to the criticisms and objections that had been made, might it not be that the formation of these companies was, in the wisdom of the Directors, decided upon because they desired to keep themselves to manufacturing business. Possibilities beyond their previous conception had come in view, and being desirous of confining themselves to certain work, they had disposed of that which would hamper them. As to the criticisms in relation to taking shares in subsidiary companies, when they knew that that was provided for by the £100,000 which less scrupulous Directors might have appropriated to revenue account, and that there was £15,000 out of profits to devote also to that amount, he did not think that they could very much complain. He thought that they might not only congratulate themselves upon a most successful 16 months in the past, but anticipate a magnificent future if they had but faith, criticised fairly and kindly, and stuck to their Directors.

Mr. Mander said that as a proof of his *bona fides* he might mention that he held (himself and partner) as many shares as any two shareholders in the Company, and he had lighted his house and works by electricity. Would it not be possible to move the Millwall works down to Wolverhampton, and thus effect a considerable economy? As far as he could make out, they had paid £150,000 more than was actually paid to those who sold the various companies to them. It made it therefore the more important that the Directors should not inflate their capital any more, either in the direction of subsidiary companies or in any other way. He would like to know whether Sir Douglas Fox left the Board entirely through pressure of engagements, or because of the formation of subsidiary companies.

Mr. J. Spencer Balfour, as chairman of the Finance Committee, answered the questions put, and said, as to Sir Douglas Fox leaving the Board, he could not conceive how it could have been suggested to the last speaker to put such a question, because, so far as he knew, since the Board had been established, Sir Douglas had never indicated any dissatisfaction. He believed the reason given for his resigning was the true one—viz., he had not the time to attend to the growing affairs of the Corporation. Sir Douglas was a great engineer, and had to run about all over Europe, so it was impossible for him to give the close and minute attention to the Company's affairs which a Chairman ought to give. And without wishing to draw any comparison (Sir Douglas was his personal friend) he could but say that the Corporation were great gainers in securing the services of Sir Henry Mance, who was by no means the least valuable asset the Company possessed. He was there every day, was well known in the electrical world, had time to attend to their affairs, and, in reality, they gained another Managing Director in him. As to the moving of Millwall works, he hoped the time would come when they would be able to concentrate the whole of the works at Wolverhampton. It was so obvious that this would be desirable, that Mr. Mander ought to have given the Board credit for having thought of it from the first. On the other hand, the transfer of a big undertaking receiving orders every day, was a very serious and expensive task. The works had only just been finished, and he thought they were indebted to Mr. Parker and everybody for the success with which they had been able to shift over from one works to another at Wolverhampton. He thought there had been some misunderstanding about the formation of subsidiary companies, and he thanked Mr. Judd for the way in which he had put the matter, which was the correct way. They had some patents of enormous value, but patents of that sort required development. In some cases hostile interests had to be conciliated; in others, other inventors had to be brought in to assist, and in these cases it was absolutely impossible for the Company to go on with its ordinary work if it had to run these patents too. It was only in these cases that the Company sought to encourage the sale of patents to subsidiary companies, and the sales had been made on such terms as would secure to that Corporation its full share of the value of these patents as the Companies came to be developed. He was not a director of any subsidiary companies. He

did not think any Director of that Board received any such salary (£1,500) as had been mentioned. The only one the question could apply to was Mr. Irving Courtenay, who was a director of the Foreign and Colonial Company. But he was a director on that board before he joined this Board. How on earth could they be simply manufacturers if the time of that Board was taken up with sending people to Rome, Madrid, or Constantinople. Surely it was better that this business should be dealt with by separate companies. With regard to head office expenses they must remember that they related to 16 months, whereas the profits only related to 12 months. But he had already proposed to the Board to overhaul the whole of the head office expenses with a view to see whether economies could not be practised. It was, however, extremely difficult to cut office expenses down to the ordinary level of ordinary business. They were asked to name a price for equipping a tramway or an electric light installation. They had to send a man down to report on such a matter, who had to get out the figures, to arrange the drawings, to meet the various legal authorities, and that man must be in manner and bearing a gentleman; he must be a highly-paid official. These expenses must inevitably be high if they were to retain some of the most profitable parts of their business. He was, however, in favour of keeping head office expenses down. He thought they should remember that the accounts had not been got up or cooked by the Directors. They had had their Auditors from the first, who gave them a continuous audit from day to day and week to week, a firm of independent accountants. The policy of the Board had been, if necessary, to over-estimate every source of expense, and to under-estimate every source of profit, so that they could bring forward accounts that they could all vouch for. He agreed that 6 per cent. was a good amount to pay on debentures. He thought shareholders would realise if they watched the market that most industrial companies had still to pay 6 per cent. on their debentures. However, they could make it five as easily as possible if the shareholders would take the debentures up at that rate. The Directors were ready to do this if the shareholders were. As to tramway and electric traction, he was talking to one of the best known engineers in the North of England lately, and he volunteered the statement that, having seen the electric tramcars at Birmingham, he considered the question of traction solved, and regarded the working there as redounding to the Corporation's credit. A question had been asked, Had all the calls been paid for in cash? Of course all the capital had to be met in cash. In some cases they took acceptances which had been met on maturity. As to borrowing they had not done so except from their bankers, who charged ordinary rates of interest. A gentleman had supposed that they had only borrowed £40,000. They had from time to time borrowed very much larger sums, and at one time they owed £140,000. So far as his friends and he were concerned they owned a third of the capital of the Company. They had, however, seen nothing to make them doubt its ultimate success, and so far as the report was concerned they had taken every pains to secure for the shareholders an honest and absolutely trustworthy one.

The **Chairman**: I think the whole of your questions have been answered by the Deputy-Chairman, and, with your permission, I will propose that the report of the Directors and the accounts annexed thereto be, and the same are hereby, received and adopted.

This was seconded by **Mr. Balfour** and carried unanimously.

The **Chairman** next moved the declaration of the dividend as proposed in the report.

This was seconded by **Mr. J. S. Balfour, M.P.**, and carried *nem. dis.*

The **Chairman** then said his next duty was the pleasing one of asking them to re-elect the four Directors named in the report—viz., Sir Daniel Cooper, and Messrs. Balfour, Courtenay, and Dibley.

Dr. Drysdale seconded.

Mr. Mander moved the election of Mr. Parker as a director.

The **Chairman** said that Mr. Mander could vote against the motion, but he was not in order in proposing Mr. Parker.

Mr. Mander said he proposed him in addition to the others, and his motion having been seconded,

A **Shareholder** suggested that the Directors should give their opinion on the matter.

Sir Daniel Cooper, in returning thanks for his re-election, said that he was connected with the old E.P.S. Company for seven years, and was a co-director of Mr. Courtenay's on that company, and he could bear out what the Deputy-Chairman had said with regard to foreign patents. Most of their attention and time had been given to the E.P.S. foreign patents, and these had given them the most annoyance and dissatisfaction. He believed dozens of agreements were made with these foreigners, but they all came to be a waste of time, and the idea of anyone in London trying to work patents on the Continent was a mere delusion. If their subsidiary companies succeeded they were certain to get something, but the other way it was impossible to get anything. This did not shape as company-mongering. He would not sit at that Board for a moment if they went into anything of the kind. Subsidiary companies brought out by company-mongers were only traps to get money out of the public. Neither himself nor any other member of the Board would be mixed up with anything of the kind for a moment. As to himself and Mr. Courtenay, he explained that they came over with the old E.P.S. Company, and were almost like an asset. They brought their seven years' experience with them, and had worked as hard as any of the Directors for the Corporation Mr. Courtenay was managing director of the E.P.S., and had an agreement with them for a certain number of years, and they would have had to pay him a considerable sum, but the Corporation had not paid him one penny. He was serving as managing director of the Foreign Patents Company, and was paid for his services by them. As to Mr. Parker's election to the Board, he was very sorry that the question had been raised. Mr. Parker was the chief working servant of the Company, and he wished them to understand that he had as good a feeling towards him as anyone in the room or at Wolverhampton, but he would not sit at that Board if an officer of the Company was to sit alongside of him. It was impossible, and the principle would apply to the smallest boy in the establishment. Supposing Mr. Parker and the Company disagreed. He would be his own master. It would be placing him in a false position. He did not say he would not sit at the table with any paid servant of the Company; he did not mean to degrade Mr. Parker, but it was impossible to control the Company properly if anyone came in that capacity to the Board. He hoped the shareholders would back up the Board. He didn't mind saying that this sort of thing would break up the Company altogether.

A **Shareholder** having expressed the same views as Sir Daniel Cooper, and **Mr. Balfour** having expressed the hope that Mr. Mander would not persist in the matter,

Mr. Mander said he did not wish to do anything contrary to the wish of the Board and shareholders. He thought Mr. Parker's election would be to the best interests of the Company, and he would be in the same position as Mr. Smith.

The **Chairman** said the speaker was quite wrong. Mr. Smith drew a large salary (and earned it too), but only had a seat on the Board. He was not an elected Director, and had no vote. Besides, he did not know how far Mr. Parker's agreements with them would be compatible with a seat at the Board. This matter had been sprung on the Board, and they could not elect Mr. Parker legally that day, the necessary notice not having been given.

Mr. Mander objected to the expression "sprung on the Board." He had given the Chairman notice some days before. However, he would withdraw his motion.

The election of Directors mentioned above was then agreed to.

The Auditors (Messrs. Broads, Paterson, and Co.) having been re-elected, the meeting terminated with the usual vote of thanks to the Chairman.

REUTER'S COMPANY.

On Saturday last an extraordinary general meeting of this Company was held at the offices, Old Jewry, Admiral the Right Hon. Sir J. C. D. Hay in the chair, to consider resolutions: (1) for increasing the capital to £100,000 by the creation of 2,500 new shares of £8 each; and (2) for altering the provisions of the memorandum of association with respect to the objects of the Company by substituting for certain sub-sections of the memorandum other sections authorising the Company to extend their operations, to carry on the business of general advertisement contractors and advertising agents in all its branches, and to construct, purchase, or otherwise acquire or work telegraphs and telephones for any of the Company's purposes.

The **Chairman** stated that they had to incur considerable expense in keeping abreast with the growing demands for telegraphic intelligence, but at present their capital was adequate for all purposes connected with that branch of business so far as it was necessary to provide agents and correspondents with funds. It might be found advisable, in the interest of their subscribers, to supplement existing services with special accounts of remarkable events, trials, fires, etc., on a larger scale than had hitherto been considered necessary, or within the scope of their general service. These, however, would be the subject of further consideration in conjunction with the newspapers themselves, and would, doubtless, be met by contributions which would recoup the outlay of the Company. The primary object of the proposed alteration of their memorandum of association and the increase of their capital was to enable them to undertake a class of business for which their organisation seemed particularly adapted—namely, the collection of advertisements for the newspapers who were their supporters. The idea had long been entertained by their Managing Director. With agencies in all the capitals of the world, who were brought into direct communication with the newspapers, the Company had exceptional means of establishing an international advertising business on a large scale, with, they believed, immense advantage to their subscribers. Some apprehension had been expressed in certain quarters that the working of an advertisement business might prove detrimental to the telegraphic service, inasmuch as the latter had to deal with financial affairs and many things that advertisers might influence. Upon this matter, they would only point to their reputation, and ask if it was likely that the Directors would commit the suicidal folly of allowing any advertiser to influence the impartiality which, they might say, had been the characteristic of their service since its creation. Indeed, it had been made a ground of reproach that their impartiality had been carried to such a length that the events they recorded were too dry. As a safeguard, however, it was proposed to keep the telegrams strictly apart from the advertising branch, and a separate staff would manage the latter in separate offices. They had taken preliminary steps abroad in conjunction with the largest advertising agency on the Continent, and as soon as they had obtained the shareholders' approval of the resolutions now submitted, and the sanction of the High Court, they would be ready to start the new machinery.

In addition to advertisement business, they believed it might be found profitable to undertake telephonic and other services, which would become feeders, as it were, of their trunk system. In short, the enlarged powers they sought to obtain would enable

them to extend their business in many directions that were now barred by their restricted memorandum of association.

On the motion of the **Chairman**, seconded by **Baron de Reuter**, the resolutions were unanimously adopted.

FOWLER-WARING CABLES COMPANY.

The second ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on Friday, the 5th inst., Mr. William Fowler in the chair.

The **Chairman** regretted that in consequence of unexpected delays they had not made greater progress since their meeting a year ago. He was, however, glad to be able to inform them that they had now obtained what it had always been their intention to have—namely, a factory in most excellent order, and ready to do a very large and, he believed, profitable business in the future. They had also obtained the services of an admirable manager, who, being resident at the factory, would be able to maintain continual supervision, which was of the utmost importance. He urged shareholders to visit the factory; and anyone who had the slightest knowledge of the subject would be thoroughly satisfied with the superior quality of the work if he inspected the samples at the London offices. As the Directors had made no profit for the shareholders in the past year they had taken no fees for themselves, although they had done a great deal of hard work for the Company. If, however, the present should prove to be a good year, perhaps the shareholders might feel inclined to consider the question of remunerating the Directors for their services not only in the current year but in the past year. He would move the adoption of the report.

This was seconded by the **Hon. J. S. Gathorne Hardy, M.P.**, and carried unanimously.

NEW COMPANIES REGISTERED.

Marine and General Automatic Company, Limited.—Registered by Andrew, Wood, and Co., 8, Great James-street, Bedford-row, with a capital of £20,000 in 4,000 ordinary shares of £5 and 40 founders' shares of £1 each. Object: to acquire certain patents for the invention of improvements in automatic electrical tell-tale apparatus, in accordance with an agreement made August 26 between W. T. W. Thackeray, J. Huer, and J. Davies, as vendors, of the one part, and J. Knowles, as purchaser on behalf of the Company, of the other part. There shall not be less than three nor more than seven Directors. The first are: Lieut.-Col. W. F. Despard, 25, Hampstead-hill-gardens; A. McKeand, 11, Pancras-lane, E.C.; T. C. St. Andrew St. John, 119, Canfield-gardens, West Hampstead; and Thomas Wilkins, 6, St. Helens-place, E.C. Qualification, £100. Remuneration: Chairman £3. 3s., and other Directors £2. 2s. each for every board attendance.

PROVISIONAL PATENTS, 1890.

DECEMBER 1.

19552. **Improvements in telephonic apparatus, the improved magnets of which may be used in other electrical apparatus or machinery.** Robert Henelade Courtenay, 17, Blondell-street, Battersea-park-road, London.

19555. **A portable room for telephone.** Frederick Augustus Oetzmann, 67, Hampstead-road, London.

DECEMBER 2.

19601. **Connecting and regulating telegraph, telephone, or electric lighting wires.** William Griffiths, 42, Tenby-street, Cardiff.

19650. **Improvements in the distribution of electricity through accumulator batteries.** Siemens Bros. and Co., Limited, 28, Southampton-buildings, London. (Siemens and Halske, Germany.)

19665 **Improvements in and relating to electromagnetic traction increasing apparatus for railways.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

DECEMBER 3.

19724. **Improvements in carriers, supports, or galleries for the shades or globes of electric lights or gas lamps** Victor Silberberg, 226, High Holborn, London.

19740. **Improvements in column printing telegraph receivers.** Frederick Herbert William Higgins, 24, Southampton-buildings, London.

19744. **Improvements in and relating to electric belts and similar appliances.** Cornelius Bennett Harness, 45, Southampton-buildings, London. (Complete specification.)

DECEMBER 4.

19762. **Improvements in and connected with electrically indicating pressure gauges.** William Colin Morison, 1, Albert-square, Great Yarmouth.

19806. **Improvements in circuit controllers or switches for incandescent electric lamps.** Norman Marshall, 45, Southampton-buildings, London. (Complete specification.)

19811. **Improvements in apparatus for use in propelling vehicles by electricity.** Frank Wynne, 46, Lincoln's-inn-fields, London.

19813. **Improvements in the production and distribution of alternate electric currents.** Albert Gay, William Frederick Taylor, and Robert Hammond, 46, Lincoln's-inn-fields, London.

DECEMBER 5.

19834. **Improvements in controlling levers of railway signal interlocking apparatus for the application of electricity.** William Frederick Burleigh, 43, Angles-road, Streatham, London.

19840. **Transforming paper or other wrapping material into sufficient strength or pertinacity to use as an insulator in all electrical matters and cables.** William Edwards and Walter Sandbach, 34, Bridport-street, Liverpool.

19842. **Improvements in roses for ceilings and wall connectors, for electrical purposes.** Wilson Henry Sturge and John Grubb, 12, Cherry-street, Birmingham.

19856. **A thermo-electric firedamp detector and alarm for use in mines.** Thomas John Murday, 41, Regent-road, Gosforth, Newcastle-on-Tyne.

19865. **Improvements in electric arc lamps.** Martial Alphonse Daveluy, jun., 55, Chancery-lane, London.

19883. **Improvements in or relating to self-controlling electrical signals for the prevention of railway accidents.** Léonard Capocci, Charles Picone, and Alphonse Spacagna, 323, High Holborn, London.

DECEMBER 6.

19942. **Improvements in galvanic batteries, and in the electro-chemical formation of chlorine and chlorine compounds applicable for such batteries and other purposes.** William Phillips Thompson, 6, Lord-street, Liverpool. (Friedrich Marse, Germany.) (Complete specification.)

SPECIFICATIONS PUBLISHED.

1889.

18361. **Electric meters.** De Ferranti. 6d.

19285. **Ships' electrical signalling apparatus.** Campbell. 8d.

20645. **Telegraph cables.** Doarlove. 4d.

20955. **Dynamo-electric machines.** Wood. 1s. 5d.

1890.

16124. **Electric clocks.** Fairgrieve. 8d.

16322. **Electric batteries.** Currie. 8d.

16324. **Battery plates.** Lloyd. 8d.

CITY NOTES.

Western Union Telegraph Company.—The Company has declared a quarterly dividend of 1¼ per cent.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the past week amounted to £5,955.

Cuba Submarine Telegraph Company.—The estimated receipts for November were £3,100, as compared with £3,112. The receipts for August, estimated at £2,900, realised £2,913.

Great Northern Telegraph Company.—The receipts for November were £23,600, making, from January 1, a total of £256,400, against £252,400 and £250,200 for 1889 and 1888 respectively.

Western and Brazilian Telegraph Company.—The receipts for the week ended December 5, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,667.

Commercial Cable Company.—The Directors have declared a quarterly dividend of 1¾ per cent., payable on January 2. It has also been decided to draw on January 2, for repayment at par, £120,000 of bonds, which will reduce the amount outstanding to £320,000. Hitherto the drawings have, it is stated, been at the rate of £40,000 a year.

National Telephone Company.—The Company announces an interim dividend for the six months ending October 31 at the rate of 6 per cent. per annum, less income tax, on the first and second preference shares, and at the rate of 5 per cent. per annum, less income tax, on the ordinary shares. Dividend warrents will be posted on the 18th inst.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1½
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	5¾
London Electric Supply	5	2
Swan United	3½	5
Crompton & Co., Pref.	—	5½
National Telephone	5	4½
Electric Construction	10	8

NOTES.

Wrexham.—The extension of telephone lines in this district is progressing.

Paris.—News from Paris says that the various public offices are shortly to be lighted by electricity instead of by gas or oil.

The Dewsbury Town Council have accepted the tender of the Electric Construction Corporation for repairing accumulators.

Conversazione. — The annual *conversazione* of the Owens College, Manchester, Union was held on Saturday evening at Owens College.

Stockholm.—The award for the Stockholm central station has not yet been made, but is expected to be settled before the end of the year.

Mill Lighting.—The weaving-shed of Messrs. J. Bury and Co., of Accrington, is lighted electrically, the installation having been carried out by Mr. Barton, of Blackburn.

Mullingar.—The award has not yet been made in the Mullingar Asylum contract. On account of the keen competition a few of the firms tendering are asked for detailed estimates.

Electric Light in Durham.—The well-known carpet factory of Messrs. Henderson and Co., at Durham, was illuminated for the first time with the electric light on Wednesday evening last.

St. James Electric Light Company.—The Right Hon. A. J. Balfour, M.P., and Mr. G. W. Balfour, M.P., visited the central station of this company at Mason's-yard, Duke-street, Piccadilly, on Wednesday.

Dublin. — The Electrical Engineering Company of Ireland are exhibiting Brush machines and transformers with arc and incandescent lamps at the Royal Show at Ball's Bridge, and have a very attractive stand.

The Guildhall.—The Court of Common Council have desired the City Lands Committee to consider and report as to the desirability of fitting the Guildhall and offices with electric lights, and the probable cost thereof.

Theatrophone.—The Theatrophone Company have definitely connected instruments to the Opera Comique. The principal clubs and cafés in Paris will shortly offer to their customers telephonic representations of this theatre.

The St. Saviour's Board of Works have referred the question of breaking up streets to lay electric mains to the General Purposes Committee. The surveyor has been reporting on the public inconvenience occasioned thereby.

Owens College.—It is proposed to add new extensions to the medical school department of Owens College, Manchester, and plans of the building have been prepared by Mr. Waterhouse, R.A. Electric lighting will be provided.

Ashton (Lancs.).—From the report of the last meeting ot the Ashton Town Council it would seem as if the Municipal Electric Light Corporation, who obtained an order for this district in the last session, are going to begin work.

H.M.S. "Pique" was launched from the Howdon-on-Tyne yard of Sir C. M. Palmer's Shipbuilding Company on Saturday. Her displacement is 3,600 tons, and she has a complete installation of electric lighting, including searchlights.

Belfast.—When will our streets be lighted electrically? asks a Belfast paper. And then, referring to the fact that Carlow has accepted Messrs. Gordon's offer (noted in our last issue), remarks that the "South can lead in some things."

Edinburgh.—At the last meeting of the Town Council, the town clerk submitted the revised provisional order for electric lighting. The Council approved the order, and empowered the Electric Light Committee to submit it to Parliament.

Royal Society.—Yesterday, Thursday, Messrs. H. L. Callendar and E. H. Griffiths were to read a paper "On the Determination of the Boiling Point of Sulphur," and "On a Method of Standardising Platinum Resistance Thermometers by reference to it."

St. Pancras Lighting.—The London County Council have approved the details of this installation as submitted by the Vestry, but suggest that where high-pressure mains are used, the frames and covers of the junction boxes, etc., shall be carefully earthed.

Electricity in Mines.—At the coroner's enquiry into the circumstances attending the recent explosion at Vivian Pit, which resulted in three deaths, Colonel Ford and Mr. Martin, mines inspector, expressed themselves in favour of firing shots by electricity as safer than fuses.

Telephone Reductions.—The South of England Telephone Company have issued notices in towns served by their lines that they have reduced their tariff to a uniform rate of £8. 8s. per annum, on a yearly agreement, for lines within one mile radius of their exchange.

Windsor.—The Windsor and Eton Electric Light Company applied to the Rural Sanitary Authority a few days ago for their consent to the company's applying for an order. After a good deal of discussion, in which some opposition was displayed, the matter was adjourned.

Theatre Lighting.—The London County Council are anxious as to the employment of electricity for lighting theatres, and so have appointed Prof. John Hopkinson to report on the danger (if any) of the various systems of electric lighting in these and other similar buildings.

Edinburgh Royal Society.—At the second ordinary meeting of this society, Prof. Ewing described and exhibited his model illustrating the molecular theory of magnetism. Mr. A. B. Brown said that Prof. Ewing had done a work of the greatest service to those who made dynamo machines.

Edinburgh International Exhibition.—The liquidator notified the guarantors by circular at the beginning of the week that to-day (Friday) he intended to present to the Court of Session an application against those contributories who had not before that date paid up their subscriptions to the guarantee fund.

Death of M. Armand Bede.—The omission of three words in our last week's note on this subject made it incorrect. The first few lines should read, "*L'Ingenieur Conseil* announces the death, at the age of 31, 'of the son' of its editor, M. Armand Bede." It is M. Bede, senior, who is the editor, and to whom we have to offer our sympathy for his recent loss.

The Archer Pipe.—The Archer Pipe Company, of Avenue-mansions, Shaftesbury-avenue, W., have issued a pamphlet, giving full details as to construction, method of laying and jointing, and the advantages of these pipes over the ordinary form. The joints are very strong, and the

pipes have great bridging power. They have been used for underground wires with success.

Cleckheaton (Yorks.).—At a meeting of the Local Board on Tuesday, four members were appointed to confer jointly with the Town Hall Committee as to the best method of lighting and heating the new Town Hall and public offices. The Town Hall Committee favoured the electric light as the illuminant, though some members of the Board declined to take part in the conference.

O.S.A. Cinderella Dance.—On Friday evening last a very enjoyable and successful dance was held at the Westminster Town Hall, in connection with the Old Students' Association of the City and Guilds of London Institute. Over 120 were present. With reference to the association, it may be mentioned that an excellent programme has been drawn up for the New Year, including four papers and three concerts.

Mechanic's Almanack.—An interesting and useful little pocket companion reaches us in the shape of "Calvert's Mechanic's Almanack" (published by Heywoods, Simpkins, Spons, and others, price 4d.). It contains a calendar of the year, with information of various kinds, but surcharged with notes, wrinkles, information, and formulæ for practical engineers, artisans, and amateurs. We notice electrical items are also included.

Gas and Electric Lighting Abroad.—At the meeting of the Continental Union Gas Company, held in London on Tuesday, the chairman stated that the electric light was making more or less progress in some of their places, and he would say "less" rather than "more," excepting, perhaps, in Milan, where, however, the consumption of gas had also greatly increased. That chairman must be more or less of an Irishman.

Sir William Thomson, P.R.S.—A movement is on foot in Glasgow among influential citizens and old students of Sir William Thomson's to get him to sit for his portrait, with the object of placing the painting in the University. Mr. Robert Gourlay, Bank of Scotland, and Prof. Jack are the joint treasurers. The Philosophical Society of Glasgow have passed a resolution congratulating Sir William on his election to the dignity of P.R.S.

Technical Literature.—We have received a pamphlet entitled "Handy Lists of Technical Literature," compiled by H. E. Haferkorn, and published in Milwaukee. The pamphlet contains a goodly list of titles of books and of pamphlets, but, like many of its predecessors, is far from perfect. It will, however, be found useful to those who are not bibliomaniacs, and who desire to know the principal books published upon special subjects.

Patent Law Amendment.—The Manchester Chamber of Commerce some time ago addressed a letter to the Attorney-General, enclosing a copy of a report upon the Patent Laws prepared by the Chemical Sectional Committee, and suggesting certain alterations with a view to ensuring more definite specifications from applicants for chemical patents. Sir Richard Webster has replied, thanking the Chamber for the report, and promising to consider carefully the proposals contained therein.

Ship Lighting.—On Saturday last the Fairfield Shipbuilding and Engineering Company launched from their yard at Govan the "Oldenburg," a steel screw-steamer of 5,400 tons, built to the order of the Norddeutscher Lloyd of Bremen. Her dimensions are—length over all, 430ft. 10in.; breadth moulded, 48ft.; depth moulded, 33ft. The vessel will be lighted throughout by electricity, provided by three direct-driven dynamos, each furnishing current for 365 incandescent lights.

Folkestone.—At a recent meeting of the Town Council the town clerk alluded to a report which had gained ground—that the electric light business had cost the town £700. This was not so. He had investigated the matter, and had found that all the expense which had been incurred by the committee did not exceed £120, and the only other charge was the fee of 50 guineas paid by order of the Corporation to Mr. Preece for his opinion.

Winter Lightning.—Mr. J. F. Cole, F.R.A.S., writes to a daily paper from Westfield, Cheam-road, Sutton, under date December 15: A most remarkable flash of lightning was seen last night in this neighbourhood at about a quarter to ten. The flash was of a beautiful white light, resembling the moon at the full, and the colour was no doubt due to the great dryness of this part of the country. Unfortunately this turns out to have been caused by the fall of an exceedingly bright meteor.

Ipswich.—At the last meeting of the Town Council it was reported that the second company who were going for a provisional order for electric lighting had promised to forward copies of the draft order. The question of overhead wires cropping up, it was stated that the Electric Light Committee had been informed that the Board of Trade would not permit any wires to be carried overhead in the future, but would probably grant a period of two years for the removal of the existing overhead wires.

Newport (Mon.).—The provisional order question was introduced at a recent Town Council meeting by Mr. Jacob, who stated that the Parliamentary Committee had been driven to ask for an order to protect the borough from the numerous companies who were seeking to get powers both last and the present year. The scheme set out in the order would not cost more than £30,000. He admitted that the electric light was more expensive than gas, but he thought it was a better light. Resolutions in favour of obtaining an order were passed.

Barking Road Cars.—The cars of the General Electric Traction Company, which have been working the Barking-road route of the North Metropolitan Tramways Company, have run during the five months ending November 27,579½ miles out of a possible 27,833, the total losses of mileage from all causes being only 235½, or ·844 per cent. During the heavy snowfall on the 28th of last month, the cars ran 193 miles out of a possible 213, which, as we remarked last week, is far and away beyond what the horse cars managed to do.

The Cambridge Philosophical Society have elected the following gentlemen to be honorary members: J. Willard Gibbs, on the ground of his contributions to physical science, and specially to the sciences of thermodynamics and electromagnetism; Heinrich Hertz, for his contributions to the science of electromagnetism, and specially for his brilliant experimental verification of Maxwell's theory; and Arthur Schuster, for his researches on spectrum analysis and on the passage of the electric spark through high vacua.

"L'Electricien."—After the 1st of January this paper and the *Revue Internationale de l'Electricité* will become one publication, which will be issued by M. G. Carré, of 58, Rue Saint André des Arts, Paris, under the title of *L'Electricien, Revue Internationale de l'Electricité et de ses Applications.* In making this announcement, M. G. Masson,

proprietor of *L'Electricien*, expresses his recognition of the services rendered to him by M. Hospitalier in his capacity as editor, and regrets that his other labours will no longer permit the latter to continue at his post.

Maidstone.—A special meeting of the Maidstone Town Council was held on Thursday, the 11th inst., to consider the question of obtaining a provisional order. The Electric Installation and Maintenance Company have given the Council notice of their intention to apply for an order, and the latter do not care to sanction the application. A discussion ensued, in the course of which the town clerk said it would cost £400 or £500 to obtain an order, and they could not move until next November. Resolutions deciding to apply for an order and refuse sanction to the above-mentioned company were passed.

Cable Across the Tyne.—The River Tyne Commissioners have granted permission to the Postmaster-General to lay a cable across the Tyne between the New Quay at North Shields and Comical Corner, South Shields, on the following conditions: That he be not allowed to claim for injury to the cable should such arise from the operations of the Commissioners; that no claim be allowed against the Commissioners in consequence of the laying of the cable; no claim to be made against navigating vessels for damage to the cable; and that the Postmaster-General remove the cable when required to do so by the Commissioners.

Electric Light in Cornwall.—Electric lights have been successfully started at the Kennal Vale Paper Mill, near Ponsanooth (Mr. S. J. Polkinhorn's). The dynamo was supplied and the work most efficiently carried out by Mr. C. J. Veale, of the St. Austell Electrical Works. The dynamo is driven by a small 8in. "Little Giant" horizontal turbine, weighing some 3cwt., and develops 6 h.p. under a fall of 24ft., carried by a flume 12in. diameter, although the power required for the dyname is only some 1½ h.p. The agent for this little machine is Mr. S. Howes, 64, Mark-lane, E.C. The turbine was fixed by Messrs. M. E. Langdon and Son, of Truro

Croydon.—The electric light has been introduced in the private residence of Mr. Radford, of Park Hill-road South, Croydon. The motor is a Crossley gas engine, which is placed in a small engine-house built in the garden, and drives the dynamo by belting. A cable runs along the garden fence into the accumulator-room, built close to the house, and the lighting current is taken from the batteries. The cables from the accumulators run to a switchboard at the head of the stairs, from whence the various circuits are controlled. The light fittings in the various rooms are very pretty. The installation has been carried out by Messrs. Cathcart and Peto, of Hatton-garden, with which firm we understand Mr. Radford, jun., is connected.

Hull.—A meeting of the Electric Lighting Committee of the Hull Corporation was held this week, Dr. W. Holden, chairman, presiding. The sub-committee presented their report, and drew attention to the fact that by the provisional order obtained last August it was incumbent upon the Corporation either to apply for powers themselves to lay down an installation within two years, or else permit some company to do so. There were no doubt numerous advantages to be obtained by the use of the electric light in Hull, and it was recommended that other towns should be visited and full information on the subject obtained. Ultimately it was resolved merely to receive the report and to consider it further at a future meeting.

King's College School.—Mr. W. H. Preece presided at the distribution of prizes at King's College School on Tuesday evening, and, in the course of the usual remarks on such an occasion, spoke of the advance made in our knowledge of the laws and applications of electricity. He gave an instance of current practice in the intercommunication by telephone between two of his assistants in Glasgow and London. Travelling, especially in foreign countries, he regarded as a means of education; and he was brave enough to defy Pope's noted couplet as to a little learning being a dangerous thing. Even a slight knowledge of geology, for example, was better than none at all.

Accident to Mr. B. Drake.—We very much regret to learn that Mr. Bernard Drake, the senior partner of the firm of Drake and Gorham, who are just completing the lighting of the new Scotland Yard offices, met with a serious accident on Friday night. After inspecting the lighting, he passed from the brightly lit corridors through an open door leading to the courtyard which had been inadvertently left open, and fell a distance of about 15ft. down an area. Considerable time elapsed before he could be removed, but he was eventually carried to the Westminster Hospital, where it was found that he had sustained a fracture of the thigh and other injuries. We are glad to hear that he is reported to be progressing favourably.

Telephone Licenses.—With reference to Mr. Raikes's reply in the House of Commons on this subject (*vide* last week's Notes), Mr. A. Erskine Muirhead writes as follows to a Scotch contemporary: "The Postmaster-General's reply indicated that there was no hurry for settlement of the license question, because the patent for the more important telephones has not expired, and does not expire until July next year; now, Sir, as this is likely to be misunderstood by the general public, will you permit me to say that for all practical purposes the patent has now expired. Mr. Preece, electrician to the Post Office; Mr. Dunn, telegraph superintendent Caledonian Railway; Mr. Fletcher, telegraph superintendent London and North-Western Railway, have those instruments now working; and, further, Mr. Houghton, London, Brighton, and South Coast Railway, has them working over a 10-mile railway circuit in London."

Leamington.—The Town Council have approved their provisional order, and sealed a memorial to the Board of Trade on the subject. The clerk was instructed to oppose applications for an order on the part of the Midland Electric Lighting Company. In replying to questions, the town clerk pointed out at the last Council meeting that they need not do the work themselves, but could arrange with other people to carry it out. He also explained that after the compulsory area had been lighted, any six occupiers of premises, undertaking to take the light for three years and ensuring them 20 per cent. return on the capital, could call upon them to supply the light to them. He thought they would have no objection to that. The order, of course, gave them power to supply the whole borough. If they did not do the work in the stipulated time, any person might petition the Board of Trade to annul the order.

Royal Meteorological Society.—At the meeting of this society on Wednesday evening, the following papers, among others, were read: 1. "Note on a Lightning Stroke presenting some features of interest," by Mr. R. H. Scott, F.R.S. On January 5, a house near Ballyglass, co. Mayo, was struck by lightning, and some amount of damage was done. A peculiar occurrence happened to a basket of eggs

lying on the floor of one of the rooms. The shells were shattered, so that they fell off when the eggs were put in boiling water, but the inner membrane was not broken. The eggs tasted quite sound. The owner's account is that he boiled a few eggs from the top of the basket, the rest were "made into a mummy, the lower ones all flattened but not broken." 2. "Note on the Effect of Lightning on a Dwelling-house," by Mr. A. Brewin, F.R.M.S. This is an account of the damage done to the author's house at Twickenham on September 23.

Gulcher New Electric Light Company.—The third ordinary general meeting of this company was held at Winchester House, Old Broad-street, E.C., on Thursday at 12 noon, Mr. D. De Castro in the chair. Prior to making any remarks on the report and balance-sheet, the chairman called for an expression of opinion from the shareholders as to whether this should not be considered a private meeting. In his opinion it was such, and if the shareholders declared it such the Press would have no excuse for saying that it was not. Mr. Harton moved that the meeting should be open and public, which was seconded by another shareholder, and carried unanimously. We shall give a full report of the meeting in our next issue. We may state, however, that it lasted for an hour and a half, and that considerable criticism was evoked by the accounts, chiefly emanating from Major Cotton, a very large shareholder and an old director.

Harbour Lighting.—The port at La Rochelle has been lighted electrically, the installation having been carried out by the firm of Buchin-Tricoche. Arc lights, mounted on iron posts eight metres 50 high are used. There are 32 lamps divided among eight circuits. Five of these circuits work eight-ampere lamps, and three six-ampere lamps. A compound Gramme dynamo supplies the current, and is driven by a 25-horse gas engine of Ravel's design, as made by the Société Nouvelle des Moteurs à Gaz Français. As a reserve, another and more powerful gas engine and dynamo will be fitted up in the New Year, so that in case of breakdown, or other cause of stoppage, the lighting will not have to be interfered with. The *Bulletin International* says that a trial was made with this installation in the presence of the municipal authorities on the 8th inst., but was not very successful owing to the failure of the gas engine to give out sufficient power, it affording hardly 10 h.p. instead of 25 h.p.

Verity's Concert.—A grand entertainment was brought about last week by the members of Messrs. Verity and Sons' Cricket Club, in a smoking concert held at Anderton's Hotel, Fleet-street. The air being thick and wreathed with smoke, amid clinking of glasses, and the (sometimes) subdued noise of conversations, the latent genius of the firm's men—of which there is much—burst forth in song or word from time to time, followed by the hearty applause of enjoyment and good-fellowship. The biggest success of the evening (in such meeting fun counts high) may be reckoned the new patent "Bigotphone Band," led by Mr. George Verity. A hushed expectancy revealed an imitation German band, in paper caps, and armed with papier maché instruments—trombones, trumpets, and all sorts "of oder tings," out of which the most excruciating funny music was produced, to the huge amusement of the listeners. During the evening, the chairman, Mr. John B. Verity, had a telegram handed in from the similar club of their newly-established Birmingham works, who were holding their concert at the same time, only sorry not to have their meeting in one and the same room under the kindly influence of the same chairman.

Plymouth.—From the report of the last meeting of the County Council here it looks as if electric lighting was in a poor way. The town clerk was asked whether the Electric Lighting Committee had met, and what prospect there was of the streets being electrically lighted. In reply, this gentleman, who by the way appears to be somewhat hazy about the matter, said that there had been nothing for which to call the committee together. At the present moment a company had obtained powers to light the town by electricity, but were not exercising them. There was a certain time limit in the Act: he could not say whether it was one or two years, within which the company had the right to exercise its powers. Until that period had expired he did not think the Council would succeed in getting a provisional order to enable them to introduce the electric light. He understood there were financial difficulties in the way of the company starting. Considering that in the opinion of several members no town of similar size was so badly lighted as Plymouth, and that the gas company receive about £4,000 per annum for this, the electrical people should wake up.

Start of the South London Railway.—The electric trains of the City and South London Subway started running yesterday morning, the first train leaving Stockwell at half-past seven. The proposed time of start had been announced previously, and the train was well filled. It performed its first public journey well and in due time, to the satisfaction of everyone. Trains were then run continuously on public service at five minutes intervals. A stoppage occurred later in the morning owing to something slightly wrong with one of the engines, but traffic was resumed after an hour's delay, and continued. As the trains have been run for many days with dummy loads everything is now in good working order. The trains are well patronised on the intermediate stations, passengers, whose time of travel on ordinary tramcars took 18 minutes, now getting to London Bridge in 4½ minutes — one quarter the time. The line seems to visitors a little overmanned at present with attendants, but this is far better than the other extreme, and it will be easy to arrange the service with the simplest staff when all is in full and continued work. The enterprise has fairly commenced its career of local usefulness, as well as world-wide stimulation of engineering undertakings in the same field of work, and will rapidly become one of the wonders and sights of London, both to country visitors and to men of engineering ability or financial standing.

Overhead Wires on the Highways.—The question of the erection of telephone poles and wires along the highways seems to be entering on an acute phase in some districts, and the Malton District Highway Board has just taken a singular step in this direction. Some time ago, permission was given to the National Telephone Company (who have of late been extending their system from York to Scarborough) to erect poles and wires along the main roads in the parish of Whitwell. Some deviation was made, however, by the company, but this difficulty was apparently got over by the Highway Board agreeing to accept an acknowledgment of 1s. per pole, instead of 6d., as previously offered by the company. At a recent meeting of the Highway Board a communication was read from the company agreeing to these terms, but the clerk at the same time submitted a letter on the subject from the Rev.

Francis Simpson, rector of Foston, calling attention to the fact that the public merely have an easement over the highway; and that any obstruction by the erection of poles thereon or otherwise is illegal. The writer held the Board had no power to grant the permission sought. A lengthy discussion ensued, and the clerk advised the Board that they really had no power to grant permission for "an obstruction of the road." It was ultimately resolved that the Board decline to enter into any agreement with the company on the subject, but to allow the poles to remain where they are under protest. This leaves the matter in a peculiar position, and it remains to be seen what steps the company will now take.

Iron Ore Discovered by Lightning Strokes.—"Lightning does not strike more than once in the same place," says the witty saying, "because it doesn't need to." But when, as a matter of fact, lightning is found to be striking time after time in the same place an explanation is needed. Iron ore is the recognised explanation now, apparently, and lightning becomes an ore prospector. Commenting upon a report that a house in Ohio, supposed to be situated over a bed of iron ore, has been struck by lightning eight times within three years, a writer in the *Chicago Journal of Commerce* says: "The truth is that all iron ore deposits are not confined to the several well-known localities of the United States where they most abound. If careful observation was made, undoubtedly many new fields might be opened up in places where the presence of iron is not suspected. The writer, in his youth, lived on a farm in Southern Wisconsin, on two acres of which lightning had struck—it was estimated—at least 40 trees. No sane man could for one moment suppose that the stricken trees of themselves possessed sufficient metallic attraction for the lightning to single them out for destruction. The suggestion made at the time that underneath these two acres was a bed of iron ore, has never been effaced; yet it is doubtful if ever any other person noticed the peculiarities of that particular plot of ground. Nature seldom errs in her indications of mineral wealth, and makes electricity a prominent agent in determining the location of iron deposits near the surface. Hence if a forest at any point shows unusual effects of lightning, or if a house becomes a peculiar attraction for it, it might pay to engage a professional inspector to develop the hidden ore."

The "Serpent's" Compasses.—Among the evidence given at the enquiry into the loss of the "Serpent," that of Staff-Commander Creak, Admiralty superintendent of compasses, goes a long way to throw doubt on the supposition that the vessel was lost owing to these necessities of navigation going wrong. He said that changes of magnetic latitude might tend to disturb the compasses, but the distance run by the "Serpent" was so short that the change would not be sufficient to make any deviation of importance. He knew of no reason of a magnetic character which would tend to carry the ship from a properly thought-out course. He had heard that the question of the attraction of the land had been raised on this subject. Three or four years ago he read a paper before the Royal Society discussing the effect of the land upon compasses placed near it. The general law derived from that discussion was that the compass was attracted by the land in the northern hemisphere and repelled in the southern. The largest amount of attraction observed was, as far as he could learn, 30min. when placed 30ft. from the disturbing cause. Such a disturbing cause at the distance of a mile would occasion a disturbance of three-millionths of a degree. Supposing the "Serpent" to approach the land, and some disturbance of which they had no record took place according to this law, the ship would be thrown off the land under Spain, the northern end of the compass being attracted towards it, as the ship must have been steering on some southerly course. The disturbance would simply tend to throw her off the land. He mentioned this to show that, taking it for granted that an attraction did take place, it would be in favour of the safety of the ship. There were no electric fittings or movable gear which would affect the compass. The covers of the lamps and compasses were made of brass. He had never met a lamp or cover in Sir W. Thomson's compasses which had occasioned magnetic disturbance.

A Big Electric Light Plant.—The Washington correspondent of the *Electrical World* says: "Bids were opened this week (Nov. 29) at the War Department, in the office of Capt. Thomas Williamson, Superintendent of the State, War, and Navy building, for the materials for the establishment in that building of a complete plant for electric lighting. The contemplated plant is intended to furnish electric illumination for the White House and grounds. There was but one bid for the dynamos, inasmuch as the advertisement called for Edison dynamos, which have been proven successful, and for which there is a necessity in this case, as other portions of the Edison system are now and have been in operation in the building for three years past, and the purchase of these dynamos will simply complete the system then established. The bids were as follows: From the Edison General Electric Company, of New York, for four dynamos, erected complete, 7,600dols.; from E. P. Hampson and Co., of New York, for two engines, 4,225dols.; from Hoover, Smith, and Co., of Washington, for two engines, 4,587dols.; the same firm, for three boilers, 3,543dols.; from the Southwark Foundry and Machine Company, of Philadelphia, for three boilers, 3,520dols. No awards have been made up to this date, but it is probable that the contracts will be given almost immediately in order that there shall be no delay in the beginning of the work. The entire plant will probably cost within 25,000dols., and will, when completed, not only light the department building, but the President's mansion, as already stated. At the present time there are about 1,600 lights used in the State, War, and Navy building. There are to be about 750 lamps in the White House, and these will make a total of 2,350 lights on the circuit. As the estimate is for a double plant of four dynamos, and the intention is to run but two of them at a time, provision is thus made for a total capacity of about 2,880 lamps. Even if all the lamps should be lighted at once, which will probably never happen, it will be possible to start both pairs of dynamos, and thus give a strong current to all. During the day there is need for only about 800 or 900 lamps in the department, although these vary as the weather condition outside changes; the White House will need its illumination only at night. It is desired to complete the work by the end of December, so as to be able to turn on the current for the New Year's reception. It is expected that all the fixtures will be in place at the White House by then, and if the plant should be delayed in any way, the lamps will be run from the city circuit. The dynamos and engines are to be located in the centre wing of the building, in the sub-basement, where there will be no noise to reach the clerks above."

UNDERGROUND MAINS.—I.

INTRODUCTORY.—TENDERS AND TRENCHES.

We purpose in the following short series of articles giving a description of some of the principal systems of underground electric mains for central station work. These articles will not go into theoretical questions of distribution, or contain mathematical investigations into the economic sizes of copper to be employed—questions which are left to be dealt with elsewhere—but will contain particulars of the actual work done in laying underground mains and conduits, together with such illustrative figures or diagrams as are procurable of the systems of central station mains in actual use at the present time for electric distribution.

The standpoint will be that of the contracting electrical engineer, the main or cable layers, and in the first place it will be worth while noting generally the points more or less common to all systems. The systems themselves may be roughly divided into low-tension and high-tension systems, but in any case the copper mains carrying the electric current require, according to the regulations of the Board of Trade, to be placed underground and properly protected in pipe or conduit.

The first necessity for parties undertaking to lay mains under the streets is the parliamentary powers under the Electric Lighting Acts. This part of the business does not concern the contractor, the main-layer, and we will suppose one of the two parties who usually require mains to be laid, an electric lighting company, or a town authority, to have already made their arrangements, and their application under the Electric Lighting Acts, and to have obtained the necessary powers for breaking up the streets.

These distributing undertakers—company or authority—may have made up their minds as to the nature of main they intend to lay down, or they may not. In all probability, in the case of an electric lighting company, some influence predisposes to a certain system of distribution, and, in the case of a town authority, the services of a consulting engineer are retained, and the consulting engineer adopts one or other system of mains according to his judgment as to the requirements, or his predilections, may suggest.

The kind of system decided upon, the next question is one of estimate or tender—private, select, or public. In the private estimate or tender the firm or company whose system it is desired to adopt is called upon to give their price for the work. The plan of the work is drawn, details are specified wherever possible, the ground is gone carefully over, and the nature of the work considered, and so the cost is worked out. The first estimate will usually be well discussed upon both sides, and often considerably modified before the definite order or contract is given.

In the case of select tenders a few well-known firms or companies will be selected by the undertakers who require mains, and the order is given to that firm or company who best and most moderately satisfy the requirements of the case, or sometimes, it is understood, by favour, the estimates of the non-successful being useful as guides to the proper price to pay for the work, no doubt according to the well-known saying that two heads are better than one.

In the case of town or other public authorities, the contract is often (though not necessarily) put up to public tender, and all who like to send in estimates, and pay a certain absurd fee for so doing, may have their estimates considered, and here usually (not without a suspicion of influence also) the lowest tender—with due consideration for the position of the tenderer—obtains the contract.

It is important to note that the method in which the tenders are to be treated varies greatly among different authorities. The most usual course in England is for the actual and final making good of the roads to be done by the highway or vestry authorities themselves, a stated charge being made if the work is not for the corporation. Sometimes the making good is to be done by the contractors to the satisfaction of the borough or vestry engineer. Occasionally, the odd course is adopted, of the authority making good, but the contractor being bound to pay for it—an item which he must include in his tender to the same authority. Then again, besides the comparative cost of system against system, or cable against cable, there is the question of material at hand and the nature of the soil. Stones, material, iron pipes and boxes, etc., may be obtained near at hand, or may have to be carried—in the case of a foreign contract sometimes a serious item. It is, of course, far better to know exactly the nature of the soil and the resources of the district, but in a foreign tender where this cannot be ascertained it must be allowed for, and naturally one tenderer is on the same equality as the others.

Having now obtained the contract, the main-layer's first care is to go through the whole scheme more carefully, arrange all the details with exactitude, and draw up the schedule of mains, material, and men required. The orders for copper or cable having been given (we do not consider the question of its manufacture here), and the material of pipes, boxes, conduits, etc., having been ordered for delivery to a special time, the notice has to be given to vestries and local authorities of the date of breaking up the street. In London these authorities will consist of the London County Council, and the local vestries—one or more as the district is more or less extensive. The consent of the London County Council is obtainable under certain conditions to be complied with as regards strength of arches, boxes, etc., for protection of the roadway. The London County Council exercise a general supervision, and have their electrical inspectors to report upon their suggestions or recommendations being carried out.

The vestries occupy a more direct control over the contractor, as it is with them the exact date of the breaking up of the roadway has to be arranged, and it is they who exercise the claims of payment for breaking up and making good the roadway. This claim in some cases, is very heavy, the St. Martin's Vestry charging, we believe, 12s. 6d. a yard for this work for each access underground, and this notwithstanding that several companies co-operate to lay or repair pipes at any one time—each must pay their 12s. 6d. per yard.

Notice has equally to be given to the gas and the water companies, and the Post Office authorities, and also, if there are any, to the telephone, fire alarm, hydraulic, pneumatic, etc., authorities, each of whom has naturally the right and desire to see that the electric light mains do not interfere with their usefulness.

The first thing in actual work upon the spot is: officers and office. The superintendent of main laying is usually a permanent official of the main-laying contractors, and a sharp, knowing, businesslike, thoroughly dependable man he must be—a gentleman in manners to meet various authorities and inspectors, capable of controlling the roughest workmen, and able to cope on the instant with all kinds of practical difficulties—and, we hope, well trusted and well paid. He usually has his own equally trusted foreman or ganger. This foreman, on the commencement of the job, he sends off into the highways and byeways, and the "weel kennt" public-houses for a supply of navvies, bricklayers, or labourers, as he may require. The superintendent himself then goes and looks out for a convenient yard and office, as a centre of work upon the district. He may have a contractor's office on wheels or he may not; but, in any case, he usually requires some place for storage of goods, and he will select this from some builder's yard, or spare shed, or piece of ground, for which he will pay a sum, half a sovereign or a sovereign a week, greater or less, according to his requirements and the situation of his work. To this place the materials of construction are sent ready for use.

By this time the labourers appear on the scene. They are passed under review, questioned, and selected or rejected according to capabilities, and hired to begin work on a certain day. The ganger should see after the men, keep the time-sheets, and should have power to dismiss any man summarily if need be, but not to engage them without the sanction of the superintendent who has charge of the job. He it is who hires all the men, lays out and directs operations, settles difficulties, corrects time-sheets, pays the men, and is responsible to his employers, the contracting firm or company themselves.

The route will usually be marked upon a plan specially prepared. The streets have to be gone over and carefully

examined. Where possible it is better to run the mains under the pavement rather than under the roadway itself, both for cheapness and ease of getting at the mains, absence of interruption of vehicular traffic, and also as less strength is then required in the construction. This, however, is not always possible. The pavement must be examined to see as far as possible beforehand what other mains are underground—the presence of telegraphs, water, hydraulic mains, etc., and cellars can be to some extent detected by the various iron boxes let into the pavement, but the gas and water pipes on the roadway cannot of course be always known beforehand, and dips and *détours* are sometimes necessary. In some parts of the principal streets of London, so full is the roadway of various mains, that the whole space when dug down seems filled with pipes—gas, water, telephone, telegraph, pneumatic, hydraulic, etc., crossing and recrossing, of all sizes, and at all depths, so that the problem of laying an additional electric light main along any extended length becomes a difficult and delicate problem. The main has to be threaded in and out, over and under, in a way that requires a system admitting of considerable flexibility, and it can be understood that systems which require straight pipes and large conduits, or which necessitate the straining of copper cables in air, as some systems do, would be inadvisable, or even impossible of application in such crowded localities. Test holes drilled or dug in the ground at certain spots would be occasionally useful to gauge the condition of an unknown road bed. In new districts this is, of course, not so necessary, and there is usually plenty of room for pipes, or even conduits of considerable size.

Having marked out the direction of the main, and settled upon the position of the road-boxes, the workmen are set to work at as many places as possible, consistent with keeping a thoroughfare. The trenches are dug, the road-boxes built in brick or concrete and properly fitted in. The mains then are laid in the trench, piece by piece and jointed, or they are drawn in after the trench is closed, according to the system of mains adopted. Tests are made of the cables, and the stones of the roadway are then replaced temporarily sufficient for ordinary traffic, notice being given to the vestry authorities, who then come and make good the road themselves. The actual details of the main laying varies, of course, with the various systems, in the manner which we shall next describe.

AN ELECTRIC MINING LAMP.

At the evening meeting of the Inventors' Institute on Wednesday, the 17th inst., Mr. S. J. Mackie, hon. sec., in the chair, a paper was read "On an Electric Mining Lamp and New Primary Battery," by Messrs. Charles Nestor Gauzentes and Walter Lucey Strong, of which the following is an abstract. The paper was illustrated by models showing that current applicable to all electrical purposes could be produced.

The scientific results claimed by the authors were—1. The maintenance of a regular and constant diagram in each element and with a single exciting fluid. 2. Constant and regular decomposition of the metal anode without production or emanation of any fugitive gas. 3. The transformation of the exciter into metallic salt without perceptible heat during the working of the battery. 4. Total suppression of all local resistances.

The mechanical or material part of the element has been greatly simplified and improved by a long course of study and experiments. Each cell now serves a double purpose, namely, first as the containing vessel; secondly, as part of the element. Two important results are thereby secured—diminution of weight and increase of surface. This double economy is of no little importance, more especially in portable batteries. The metal which serves as the anode of energy is refined by a new and simple process, and effects the maximum production of current without fear of rapid polarisation, which up to the present has in other primary batteries proved the great obstacle to the practical employment of this direct source of electricity. The fluid which serves as exciter is a novel combination, giving in a single liquid all the properties necessary for the production of a regular and constant current, not only from the dynamic point of view, but also in the re-absorption of the sulphates produced. This new fluid can be manipulated without the slightest danger either in preparation or in use. It is at present the exclusive property of Messrs. Gauzentes and Strong, and a secret.

The miners' lamp, which was shown of full size and in action, possesses the following advantages: Its weight does not exceed 3lb. 12oz.; it gives a regular and constant light for 14 hours; the cost of maintenance for a week's work calculated at from 72 to 80 hours does not exceed 5d., all charges included; the cost of construction of each lamp does not exceed 5s.; the battery can be guaranteed to last for five years; the interior resistance does not undergo any alteration during that period.

As a matter of practical employment, whilst eliminating all sources of danger, whether by explosion or fire, the new lamps give greater light, and that light is produced at a cheaper rate, than the ordinary lamps in general use. The safety lamp now used in the mines gives an illuminating power equal to $\frac{1}{17}$th of a candle. Supposing this power can be regularly maintained for 12 hours, the lamp will then have given a total light of $\frac{12}{17}$ths of a candle. The new electric lamp has an illuminating power estimated at $\frac{2}{3}$ths of a candle, consequently its total light in the same period is equal to eight candles. That is, a light nine times greater in quantity and 11 times greater in effect upon the surface to be illuminated in consequence of the power of diffusion. The existing ordinary miners' lamps, giving $\frac{1}{17}$ c.p., cost 3½d. per week. The new electric lamp, giving nine times that light and offering every security, costs 5d. per week, thus showing a great economy over the ordinary lamp, and which to give an equal light would cost $3\frac{1}{2} + 9 = 31\frac{1}{2}$ pence. These results have been verified over and over again with the greatest care. No serious objection, therefore, can be advanced against the adoption of the new electric light lamp on the cost of maintenance, and still less on the point of cost of construction.

From the practical standpoint of actual use in coal mines repeated experiences do not leave a doubt upon the matter. Some letters of testimony were then read, amongst them one from the manager of a large mine in one of the most important coalfields, that of the Rhondda Valley, in South Wales. The author also referred to the test of one of these lamps made by the honorary secretary of the institute (Mr. S. J. Mackie), who had it specially confided to him for the purpose.

The authors showed a portable table lamp, a pocket lamp, and medical and laboratory batteries, and an automatic battery consisting of groups of elements arrayed in sections for numbers of lamps or for traction.

The table lamp gives the happiest results alike in its security from fire, its cheapness in use, and its illuminating power. The pocket lamp is for railway reading, theatrical ballets, and other purposes. Having succeeded in decomposing the materials necessary for the production of electric current without emanations, these small batteries can be hermetically closed, and in this way their practical applicability is evident. Objecting to the use of artificial resistances, which in reality mean a loss of part of the energy developed, the authors have constructed and combined the elements of their medical and laboratory batteries in such manner as only to produce the current required. Above all, it appears to them that it is more rational to act upon the source of the current than upon the external delivery of it.

Discussion.

Mr. James asked whether the internal resistance did not increase in course of time, and as to the gas evolved?

Mr. Jarman asked whether the E.M.F. did not fall as the zinc was consumed, for he imagined it was zinc, and the internal resistance increase as the metal was attacked by the liquid? As to cost of producing the current for traction or other purposes, if chemical laws were right they would have to consume 65½lb. of zinc where 12lb. of coal would do.

Mr. Mackie (the chairman) spoke in favourable terms of the battery, and read a letter from a Mr. Steele in the same strain. **Mr. Thorpe** also spoke.

In replying, Mr. Strong said he did not say there was no emanation of gas. There was, but it was absorbed as fast as evolved, and that was why they could hermetically seal their cells. As to a fall in the E.M.F., of course the battery was not a perpetual one, but they could keep it going constantly for 10 hours, and as a matter of fact had done so for 21 hours. The only answer he could make to Mr. Jarman's question as to the consumption of zinc was, could he get 5d. worth of coal to give him that light (holding up a miner's lamp) for 72 hours. He (the speaker) did not believe he could.

THE CITY LIGHTING.

At the fortnightly meeting of the Commissioners of Sewers, the question of the lighting of the western district of the City by electricity was settled.

Mr. Cloudsley (the chairman of the Streets Committee) submitted a report relative to the tenders for lighting the western district of the City by electricity, and recommended that the proposal of the Brush Electrical Engineering Company, on similar terms to those contained in the agreement for the central district, should be accepted. The committee also recommended that the application of the Brush Electrical Engineering Company for the consent of the Commissioners to their application to the Board of Trade for a provisional order should be granted, subject to a contract being executed as in the case of the central district. In their report the committee stated that the arrangements for the lighting of the western district of the City of London were on similar terms to those arranged for the east and central districts. In response to the advertisement tenders had been received from the Brush Electrical Engineering Company and the Electric Installation and Maintenance Company. These two tenders had been referred to the officers with a view to the preparing of a comparative statement to ascertain the financial position of the parties, and whether they had given the necessary statutory notices of their intention to apply for provisional orders. Their officers had reported that the tender of the Brush Electrical Engineering Company was on similar terms to those contained in the agreement entered into with them in respect to the central district, except that the power of the "glow" lamps was not specified. The company had given notice of their intention to apply to Parliament for a provisional order in respect to this district similar in terms to that granted last year, except that in such order only four streets were proposed to be provided with mains, instead of 18 streets mentioned in the original specification, and the company to be allowed two years to lay such mains instead of 21 months. The Electrical Installation and Maintenance Company in their tender accepted generally the conditions of the contracts, but it appeared that the company were not able, with their own resources alone, to carry out the work of publicly lighting the district, but they had entered into a provisional contract with the Electric Construction Corporation for the construction of the whole of the works. They had not given notice of their intention to apply for a provisional order this session. The committee had very gratefully considered the tenders, and they unanimously recommended that the tender of the Brush Electrical Engineering Company for lighting the western district should be accepted, and that it should be referred to the solicitor to prepare the necessary contract to give effect thereto. The committee, in their report, further stated that they having had under consideration the application from the Brush Electrical Engineering Company for the formal consent of the Commissioners, as required by the Board of Trade, to the provisional order for which they were applying to light the western district of the City, the committee recommended that a resolution should be passed consenting thereto, subject to the contract being executed, as in the case of the central district. The committee had also had under consideration the application of the Brush Electrical Engineering Company for Blackfriars Bridge to be included in their area of supply with a view to laying their mains from their proposed central station to the subway in Queen Victoria-street, and the committee recommended that the company should be referred to the Bridge House Estates Committee, as having the control of the bridge, and that a letter should be addressed to that committee in support of the application.

Mr. Cloudsley, in moving the adoption of this report, said the subject was so old a one that he need not enter into details upon it. The Streets Committee had spent a very long time in discussing these tenders, and they had been assisted by Mr. Preece, their electrical engineer, and with his advice the committee unanimously came to the conclusion that this tender of the Brush Electrical Engineering Company was the one which should be accepted, and he had no doubt that the Commissioners would agree with the Streets Committee.

Mr. Morton said he should like to ask when any portion of the City would be lighted by electricity.

The Solicitor said the contractors had commenced work in the main thoroughfares, and these would be completed within nine months from the date of the contract—namely, May 19.

The Chairman stated that the Brush Electrical Company were already engaged in preliminary work which must be done before they could venture to apply for permission to open the streets.

Mr. C. T. Harris said he would not go into details, but he must say that he, as a member of the Commissioners, would never consent to a contract which undertook to give a monopoly in private lighting for a period of 21 years, or, indeed, for any period. As matters stood at present the Commissioners of Sewers, as the local authority, must oppose any other company which would seek for powers in parts of the City.

Mr. Pannell, interrupting, thought that the position of things should be explained. He did not think the hon. member was in order. The fact was that two districts in the City had been taken up and certain terms come to, the Commissioners arranging to take the tenders on similar terms. He asked, therefore, whether the hon. member was in order in discussing contracts already agreed to?

The Chairman said he believed the terms had already been agreed upon.

Mr. C. T. Harris contended that such was contrary to Colonel Majendie's report, he being of opinion that it was desirable that two companies should be in every district. He reminded the Court that the alternating supply did not supply force for motive power; that it was useless for motive power, and the Commissioners could not help themselves because they had bound themselves to oppose any company on the direct supply principle. To manufacturers in the City, probably, a motive power in the future would be absolutely necessary.

Mr. Shaw, rising to a point of order, said this question had already been discussed at considerable length, and they were now told that the terms were similar.

The Chairman: They are identical.

Mr. Sly rose to a point of order.

The Chairman: I want Mr. Shaw to conclude his remark.

Mr. Shaw: The question I ask is, Has not this which Mr. Harris has been speaking upon been decided already?

Mr. Bridgman: Is it not in order for an hon. member to speak upon a contract that is about to be entered into?

The Chairman: If Mr. Harris had been out of order I should have ruled it so.

Mr. Harris, continuing, said in the district he was familiar with—namely, in Victoria-street, Westminster—there were two electrical companies working, and consumers had the choice, and the direct-supply system was preferred because it was a low system and would supply motive power. He believed that in years to come the Commissioners of Sewers would be placed in an unfortunate position in respect to their present action with the consumer. He repeated that he would never consent to a contract which gave a company an absolute monopoly for 21 years, or, indeed, any period. It was an exclusive supply that the Brush Company wanted, but he thought in the interests of the consumers that this was most undesirable.

Mr. Pannell said on the last occasion when this subject was under discussion here, the Commissioners resolved that the committee should be at liberty to invite tenders

on the basis of the tenders already accepted, and the committee were empowered to obtain what better conditions they could. The committee found that they had only two applications before them, and one of these tenders, their technical adviser told them, did not come within the contract form at all. Being so advised, they had only to deal with the tender before them, and this tender had been made by a company which had given notice to apply to Parliament for an order in the ensuing session. If the Commissioners did not accept this one after six years' consideration on the subject, much delay would ensue, and after listening to the last speaker, a new member of the Court might very well imagine that this was the first occasion upon which the subject had been discussed. But these points had been disposed of years ago. After six years' consideration the committee now unanimously recommended the acceptance of this tender. If the Court did not do this it would put the lighting of this district by electricity back another year or more.

Mr. MORTON asked how far the private consumer was protected in this matter.

The SOLICITOR replied that the consideration of the committee had not been so much in regard to the private consumer, because they had to deal with public lighting; but the private consumer was protected by a sliding scale, by which, if the profits of the company increased, the cost to the consumer decreased.

Mr. MORTON: But is there a limit?

The SOLICITOR: Oh, yes, there is a limit.

The report of the committee was then unanimously agreed to.

NOTES ON THE CHEMISTRY OF SECONDARY CELLS.*

BY PROF. W. E. AYRTON, VICE-PRESIDENT; C. G. LAMB, B.SC., AND E. W. SMITH, ASSOCIATES.

(*Continued from page 524.*)

For the sake of comparison, the percentage of PbO_2 at A in the following table is taken as 47·9, as at C'.

The calculations refer to mean values of PbO_2 and the values of the P.D. before breaking circuit.

	Interval.	Increase per hour in percentage PbO_2.	Percentage increase in P.D. in interval.	Percentage increase in PbO_2 in interval.
Charge.	A to B	3·0	3·1	27·6
	B to C	4·8	1·6	8·8
	C to D	3·8	7·4	10·8
	Interval.	Decrease per hour in percentage PbO_2.	Percentage decrease in P.D. in interval.	Percentage decrease in PbO_2 in interval.
Discharge.	A' to B'	4·3	2·1	31·7
	B' to C'	3·6	5·4	16·3
	C' to D'	2·6	67·4	6·5
	D' to E'	1·6	100·0	5·4

The screening influence of lead sulphate is clearly brought out in this table. Between A and B the surface film and the coatings on the partially reduced granules of PbO_2 are got rid of; then between B and C the pure lead sulphate is attacked; and finally, between C and D, with the removal of the last traces we get a very rapid rise in volts P.D.

It will be observed that:

(*a*) The particles of the peroxide very soon get coated in the discharge with a layer of lead sulphate, which protects the peroxide from further action, as shown by the examination of the dark-coloured residues which contained peroxide, and which were rendered very hard to dissolve by the coating of sulphate.

(*b*) The analysis also shows what a large proportion of active material is still remaining at the end of the discharge. This has been remarked on by many experimenters.

(*c*) The loose powdery surface of the positive plate seems to be thoroughly converted into lead sulphate. C and B' dissolved readily, leaving pure white residues.

(*d*) When the peroxide in the surface of the plate falls to about 31 per cent. the cell loses its E.M.F. very rapidly, owing to the inactive layer of sulphate impeding the action of the sulphuric acid on the active material behind it, and also to the formation of peroxide on the negatives. The diffusivity of the acid is decreasing, and it has to penetrate further into the plate to find active material. When the whole of the paste approaches this composition of 31 per cent. peroxide, the cell loses its E.M.F. entirely.

(*e*) The action seems to take place most rapidly where the current density is greatest; the plate gets hard there from sulphate soonest on discharge, and oxidises quickest on charge.

Planté and Messrs. Gladstone and Tribe have both noticed the formation of peroxide of lead on the negative plate during discharge, and pointed out that once it is formed more rapidly than it is reduced, the two plates must rapidly approach electrical equilibrium; that when the circuit is broken local action alone can take place, and this will reduce the peroxide on the negative plate, and on making the circuit again the cell will again give a current; and in this way Messrs. Gladstone and Tribe account for the resuscitating of the cell, as well as for the rise of E.M.F. on breaking the discharging circuit.

I have to acknowledge the facilities afforded me for seeing the plugs as they were removed, and the care taken to let me have the samples in good condition.

I am also indebted to Prof. Armstrong for his invaluable advice and assistance in the execution of the work.

G. H. ROBERTSON.

From the mean results of the preceding analysis carried out by Mr. Robertson, we have drawn the curves seen in the lower part of Figs. 1 and 2, and which show the percentage of PbO_2 found in the plugs of the positive plate at all stages of the charge and discharge. In the PbO_2 curve for charge the first point is obtained from the analysis of the plugs at the end of the normal discharge—that is, when the terminal P.D. had fallen to 1·85 volts, indicated by the point C' in Fig. 2. The percentage of PbO_2 actually found in the positive plugs at the point indicated by A, Fig. 1, does not lie on the PbO_2 curve as drawn, but, as already indicated, this arises from the specimens removed from the plugs at experiment A being only scrapings off the surface, and therefore not representing the average constitution of the plugs. On all subsequent occasions when specimens were removed from the plates whole plugs, as already stated, were detached. The analysis at the point A, Fig. 1, was therefore abnormal, and the percentage of PbO_2 obtained for this point, and which is given in the table, is not indicated on the curve.

If the energy given out by the cell be produced by the conversion of PbO_2 in the positive plugs, and of Pb in the negative, into lead sulphate, a constant value of the P.D. at the terminals of the cell when a constant current is passing through it ought to correspond with a constant rate of variation of the percentage of PbO_2 in the positive plugs, so that for a constant current

$$\text{the terminal P.D. should} \propto \frac{d\,(PbO_2)}{dt},$$

t representing time. This connection is seen to exist fairly well in the case of the discharge where the slope of the PbO_2 curve is roughly constant as long as the P.D. is constant, and acquires a less inclination to the axis of time when the P.D. is rapidly falling. In the case of the charge, the connection between the value of the P.D. and the slope of the PbO_2 curve is not so easily seen; but this arises from the fact that towards the end of the charging there is a rapid rise in the resistance of a cell, and therefore in the P.D. required to send a constant current through it; further, the back E.M.F. steadily increases during charging on account of the polarisation, which grows larger and larger from the continuous evolution of gas at the surface of the plates.

FIG. 10.

FIG. 11.

As already explained, the constant discharge current of 10 amperes was, by the employment of some auxiliary cells, kept flowing through the accumulator under test even when its E.M.F. became very small. Towards the end of the discharge the fall of P.D. at the terminals of the cell under test became extremely rapid, so that, for example, on closing the circuit after the removal

* Paper read before the Institution of Electrical Engineers.

of the plugs at D', Fig. 2, the P.D. fell from 1·9 to 0·6 volts in 33 minutes, as seen from Fig. 10. This rapid fall is probably due to lead peroxide being formed on the negative plates more rapidly than it could be removed by local action, since the chemical analysis showed decided evidences of lead peroxide on the plugs removed at D' from the negative plates. At E', Fig. 2, the E.M.F. of the accumulator under test became reversed, but rapidly recovered its original direction on stopping the discharge current, as seen from Fig. 11.

It is a very striking example of the recuperative action of a secondary cell that you can completely discharge it, as you think, and then even charge it in the wrong direction, but it will, on being insulated, rapidly recover an E.M.F. in the original direction. Indeed, we were told of a curious case some time back. After the removal of the laboratory employed for testing ammeters from one part of a well-known London factory to another, it was found that the E.P.S. accumulators always ran down very rapidly whenever an attempt was made to use them, in spite of their having been charged in the intervals. As the E.M.F. was always in the right direction, it was supposed that the cells had become partially short-circuited in the removal, and it was not for some time that the true explanation of the refusal of their cells to do their work was discovered. The real fact was that in fitting up the new laboratory, the leads from the dynamo to the switch had been reversed, so that the unfortunate cells were charged in the wrong direction every time the dynamo was turned on.

The preceding incident also forcibly illustrates the sort of attention that secondary cells may receive in practice, and shows the necessity for the P.D. and specific gravity being occasionally measured even in places where the study of the behaviour of cells is not the main business of the factory.

One of the great defects of the earlier specimens of the E.P.S. cells lay in the buckling of the plates. Mr. Capito tells us that it was Mr. Collet who noticed that all the plates generally curved in one direction, and who suspected that this arose from the unequal chemical action on the two sides of the last positive plate of the cell. Mr. Collet therefore proposed putting a negative plate at each end of this cell, and this plan, which has been always followed since, of using one more negative than positive plate, has had much to do with removal of the buckling difficulty.

V.—Effect of Rest on Charged Accumulators.

As the result of a number of tests described in our Edinburgh paper, we found that if E.P.S. accumulators be charged with nine amperes and discharged with 10, a number of times without intermission, between the P.D. limits of 1·8 and 2·4 volts per cell, until the cells are brought to a perfectly steady "working state," the quantity efficiency is about 97 per cent., and the energy efficiency 87; further, that if the cells be fully charged until the P.D. per cell is 2·4 volts, and then be left perfectly insulated for 16 days, the next discharge between the fixed P.D. limits only gives out about 65 per cent. of the ampere-hours, and about 57 per cent. of the energy put in before the rest. Further, not merely is energy lost during the rest of an insulated accumulator, but for several subsequent charges and discharges between the same P.D. limits after the rest the storage capacity and the quantity and energy efficiencies are all lower than before the rest.

For the purpose of examining into what took place in an accumulator which was left charged, a small E.P.S. cell was charged until the P.D. was 2·4 volts, and then the positive plates were withdrawn and put into another vessel containing dilute acid of specific gravity 1·2, the negatives being left in the vessel in which they were charged. Both sets of plates were covered up with guttapercha hoods the edges of which dipped under the liquid, and to the top of each hood was fitted, gas-tight, a vertical graduated glass tube closed at the top. The hoods and the glass tubes were first filled with liquid, and the amount of gas that came off from the two sets of plates was measured from day to day by watching the descent of the liquid in the tubes.

No gas was seen to come off from the positive plates, but in the case of the negatives gas came off very slowly at first, then more rapidly, and finally more slowly again. The following table gives a record of the amount of gas that came off from the negative plates, the gas, on analysis, being found to be hydrogen*:

Hydrogen Gas Collected from Charged Negative Plates after Removal of Positive Plates.

Date.	Time.	Cubic centimetres of gas collected.	Time of collecting gas, in hours.
	H. M.		
November 15th	11 45	0	0
" 17th	10 0	2	46
" 20th	12 0	52	120
" 21st	10 0	72	142
" 22nd......	10 0	87	166

If the lead of the positive plate be turned into lead sulphate by local action, 87 c.c. of hydrogen liberated corresponds with about 0·81 gramme of lead turned into sulphate. It is clear, then, that the lead of the negative plate is steadily being turned into some oxide or salt, and probably the loss of energy which we observed in the charged cell left insulated for many days was due to this local action at the negative plate. And, further, as this action takes place apparently only at the negative plate, it is clear that in subsequent discharge the cell will appear to be discharged before the positive plate is discharged, and charged up again without reducing all the lead sulphate on the negative plate. The local action at the negative plate while a cell is standing charged has, therefore, for the first few discharges and charges after a long rest, exactly the same effect as if a portion of the negative plate had been bodily removed out of the cell. Hence, we see that the peculiarities observed by us in curves 8 to 23 in our Edinburgh paper may be explained by this defective behaviour of the negative plates.

* Since the preparation of this paper we have noticed that Dr. Gladstone and Mr. Hibbert, in their paper communicated this summer to the Physical Society, have also observed that hydrogen comes off from a charged negative plate of a secondary cell when left idle.

VI.—Construction and Formation of E.P.S. Plates.

The question arises why the E.P.S. accumulators are so constructed that the plugs in the positive plates contain some 48 per cent. more peroxide of lead than is required to be converted into sulphate in the normal discharge. Two explanations suggest themselves. One is that, since the granules of lead peroxide begin, as we find, to be coated with a protecting coating of sulphate early in the discharge, it is impossible, with the present form of plate, for the interior of each granule of lead peroxide to be converted into sulphate, and, therefore, it is necessary to employ nearly twice as much lead peroxide as is actually needed for the chemical action. Another reason is the fear of the positive plate crumbling to pieces if it be completely formed. And this reason Mr. Capito, who was formerly in the employ of the Electrical Power Storage Company, thinks, on the whole, is the more important.

In the construction of the original Faure accumulators, as well as of the early E.P.S. cells, both the positive and the negative plates were pasted with red lead (Pb_3O_4), and formed together for a period of some 50 hours. Later on litharge (PbO) was used to coat the negative plate, red lead being used only for the positive one, and the plates were formed separately, the negative being much more formed at the works than the positive. Some time ago I was informed by a very competent authority that the following is the modern process of forming employed by the Electrical Power Storage Company:

Positive Plates.—$8\frac{1}{4}''$ by $7\frac{1}{4}''$ by $\frac{1}{4}''$. Two amperes per plate, or 0·028 ampere per square inch, sent for 18 hours.

Negative Plates.—9" by $9\frac{1}{4}''$ by $\frac{3}{16}''$. One and a half to two amperes per plate, *i.e.*, 0·017 to 0·023 amperes per square inch, for 120 hours.

The actual time of forming either set of plates depends greatly on the length of stoppages during the formation. This is especially the case with the negative plates, therefore they endeavour to form the negatives for the 120 hours without any stoppage of the current. On the receipt of a cell from the Electrical Construction Corporation, the purchaser is requested to form it for 40 hours more with the ordinary charging current used in working, which is at the rate of 0·026 ampere per square inch.

Mr. Capito tells us that, when he was at Millwall, such periods of formation as 120 hours were not used; and he thinks that this may be due to the fact that formerly the plates were not dried after pasting and before formation, as they are at present. This drying hardens the plate and produces a better cell; but he thinks that, as the paste is itself mixed with sulphuric acid, there is probably some sulphating of the negative plates during drying, and that several hours in the subsequent formation are probably spent in reducing this sulphate.

The reason, we understand, for the manufacturers only forming the positive plates for 18 hours, and leaving the purchaser to form them for the remaining 40 hours, is that if positive plates be well formed and then dried for carriage, the plugs become loose, which is not the case if the positive plates be only slightly formed before drying.

We were interested in learning from Mr. Capito whether, while superintending the manufacture of many thousands of accumulator plates, he had ever tried pasting the positive with lead peroxide (PbO_2) in order to avoid the necessity of having to form this salt electrically out of the red lead with which the positive plates are usually pasted. The idea of applying a paste of lead peroxide directly to the positive plate, he told us, he had tried, but that the method turned out a failure, from the impossibility of getting the lead peroxide paste to stick on to the grid even when some red lead was mixed with the lead peroxide. He also mentioned a very interesting fact—that whereas a paste of red lead mixed with dilute sulphuric acid of density 1·1 gives an adherent deposit on formation, on the contrary, a powdery deposit is produced if the density of the liquid used in making the red lead paste be 1·2. We understand the process that has shown itself the best is to use dilute sulphuric acid of density 1·1 for mixing the red lead paste, and dilute acid of 1·2 for mixing the litharge paste for the negative plates.

Discussion on "The Chemical Action of Secondary Cells," by Prof. W. E. Ayrton, F.R.S., C. G. Lamb, B.Sc., and E. W. Smith; and on "The Working Efficiency of Secondary Cells," by the same Authors and M. W. Woods.

(*Authorised Abstract.*)

In opening the discussion, **Dr. Gladstone** said he had been greatly interested in the points brought out by the authors and in the account of the elaborate experiments described. He was rather surprised that taking out so many plugs from the cell had not

greatly damaged it. The chemical results arrived at, he considered, confirmed the views put forward by himself and Mr. Tribe about nine years ago, as to the action of cells resulting in the formation and reduction of ordinary lead sulphate. Since that time, however, many statements had been made attributing important functions to subsulphates, but so far as he and Mr. Hibbert had investigated the matter, such statements had not been confirmed. They now believe that the so-called subsulphates are probably mixtures of ordinary sulphate and peroxide. Referring to the difficulty experienced by Mr. Robertson in analysing the powdered sulphate, he pointed out that ammonium acetate could be used for dissolving out the sulphate. Results obtained by this method showed the sulphate to be the normal one, and he did not think the solvent would alter any subsulphates if such were present. In his opinion there could be no doubt but that the sulphate surrounding granules of peroxide would act as stated in the paper, and diminish the capacity of the cell. Speaking of the gas given off by the negative plate, he said the fact had been alluded to in a paper by Mr. Hibbert and himself recently published in the *Philosophical Magazine*. They, however, had not observed the great differences in the hardness of plugs at different parts of the plates. This result he considered important, and thought it would lead to a modification in the form of plates.

Mr. Crompton said that for some time past he had been working on the subject of secondary cells, and had arrived at results similar to those brought forward in the paper. One great advantage, however, of the results contained in the communications under discussion arose from the fact that they were obtained from cells of a different type from those he had experimented on, for if he himself had brought the result before the institution it would have been thought that the actions were peculiar to his kind of cell. As regards the "gassing" of cells, he had found it due in a great measure to light. Both sun light and arc light increased this action, and quantitative experiments were now being made. He was glad to see the statements of the advocates of secondary batteries, as regards efficiency, had been confirmed. They had, he said, been accused of exaggerating their efficiency, and not without cause, for the cells themselves behave peculiarly, as, for example, the 105 per cent. quantity efficiency mentioned in the paper. Such results seem impossible, and showed the necessity of getting cells into what the authors had called "the steady working state." He regretted that "proof plates" had not been used in the experiments on the running down of cells. He had used them for a long time, and always found the negative discharged first. If, however, very thick negatives were used, there was no sudden drop in the potential difference, such as indicated in Figs. 2 and 3. In endeavouring to measure the resistance of the cells with a view to determining the best proportions of plates and liquid, he had met with great difficulties, and he now believes that what is usually measured is of the nature of a back E.M.F. This he supported by saying that the so-called resistance did not seem to vary either with the thickness of the plate or their distance apart, or with the density of the acid. During his investigations a rosy colouration of parts of the liquid had been noticed in some cells. The coloured portions may either appear as strata, lines, or in tree-like forms, and in some cases resemble the shapes of magnetic lines of force. These peculiarities, he hopes, may give some idea of the electric stresses and strains within the electrolyte. The recuperative power of discharged and reversed cells was very marked, for he had observed it in cells that were half charged in the reverse direction, and on cutting up the plates, layers of different materials could be seen. This fact shows how important it is to thoroughly charge cells of the Planté type during formation by reversals. Until quite recently negative plates had been considered faultless, and the positives blamed for defects which were in reality due to imperfections in the negatives. He knew of no case in which positives had gone bad when their negatives had sufficient capacity, and for this reason the negatives ought to be made thicker or larger than the positives. "Sick cells," he said, get partially sulphated and the negatives run down; when the E.M.F. falls below 1·3 heavy sulphating of the positive occurs, and so-called "irreducible" sulphate is formed. In his opinion, the reducibility or irreducibility is merely a question of its position, or of its contact or want of contact with the conducting material. In conclusion, he suggested that E.P.S. cells might be improved by reducing the size of the plugs so as to bring the active material closer to the lead backing.

The discussion was then adjourned.

At the meeting on November 27 the discussion was resumed by **Mr. Crompton**, who directed attention to three diagrams which he had prepared since last meeting. One of these showed the character of the colouration seen in the electrolyte when received from the top. Curved lines or shells start from the positive plates, and turn away as if repelled from the cell terminals. In one cell, which had its + and − terminals at opposite ends, the lines curved towards the middle of the cell, whilst in another, where the terminals were left at the same end, they bent towards the opposite end. The second diagram exhibited the influence of the rate of discharge on the capacity of a cell having 11 5lb. plates. When discharged at one ampere per plate its capacity was 300 ampere-hours, but at six amperes only about half. The fall of volts was very sudden at the end of each discharge. The third diagram related to the discharge of an experimental cell, containing seven 9lb. plates, and showed that although the capacities were not very different from those of the 11-plate cell, the fall in volts was not nearly so sudden.

Mr. Reckenzaun said the papers under discussion were very important ones, and contained much that had never been published before. Many of the facts, however, were known to those engaged in the manufacture. The question of efficiency, he thought, was not likely to be settled, since, according to the authors, it may vary between 105 per cent. and 58 per cent., depending on the previous history of the cells. In his own experiments on the effect of prolonged rest he had found a similar loss of efficiency, and he believed this to be due to sulphating of the negatives. The negatives were always played out first, and this defect could not be got over by making them abnormally thick or increasing their surface, for if thickening be tried the interior is not acted on, whilst greater surface gives no advantage on account of the material being at different distances. To test the deficiency of negative plates he had discharged cells as low as possible and then put the positive with a newly charged negative, from these a fair E.M.F. and discharge were obtained. He had also tried amalgamated zinc instead of a newly charged negative; and got 40 per cent. of the original capacity. Then facts account for the existence of PbO_2 in the positive plugs when the cell was supposed to be completely discharged. In his opinion it would be better to say that the negatives were discharged too soon. The negatives of Planté cells, especially those formed by the nitric acid process, soon lose their virtue, and this was attributed to the difficulty in removing all the forming acid. In the course of his remarks, Mr. Reckenzaun said he had received a very interesting diagram from his brother in America, showing the E.M.F., current, density of acid, temperature of cell and of surrounding air, etc., during the charges and discharges of a secondary battery; this diagram he would place in the hands of the secretary.

A communication from **Mr. Hall** was then read. This related to a pair of E.P.S. plates recently taken from the battery under his charge at the P. and O. Company's offices, where they had been in constant use for six years. During that period the cells had supplied about 150,000 ampere hours and were still in good condition, as was indeed evident from the appearance of the plates shown. In the working of the battery, the density of each cell had been carefully watched and any defect promptly removed. His experience confirmed the observations of the authors on the effect of rest.

Mr. W. Hibbert, referring to the Edinburgh paper, said he would first deal with the high E.M.F. at the end of a charge, and its rapid fall on breaking the circuit. In a communication made to the Physical Society last June, Dr. Gladstone and himself had shown reason for believing this to be due to concentration of acid about the positive plate and its subsequent rapid diffusion, and he thought the results plotted in Fig. 6 of the paper under discussion, showing the effect of making and breaking the circuit of a charged cell on its E.M.F. and P.D. were consistent with the idea. Further on in the same paper the authors say that the concentration hypothesis will not explain the rise of P.D. in a cell discharging after a long rest. On this point he, Mr. Hibbert, said that the reactions in such states were very complex, but still he thought it would be possible to find an explanation of this phenomenon based on similar lines.

(To be concluded.)

THE NEW OLYMPIC THEATRE.

A special electric lighting plant has been erected at the new Olympic Theatre. Two compactly-arranged rooms have been provided in the basement below the scene dock, and situated a little distance from the auditorium, for the accommodation of the engines and dynamos. In the boiler-room are erected two Davey-Paxman locomotive type boilers, each of 60 h.p., with the feed pumps and injectors. The former work at a pressure of 150lb., and the latter are operated by the exhaust steam, the feed to the boilers being at about 200deg. From the boiler-house the main steam-pipes pass into the adjoining engine-room, which contains three compound high-speed Globe engines, of 40 nominal h.p., and three dynamos. Two of the engines, which run at 390 revolutions per minute, are coupled direct to the shafts of two of the dynamos, whilst the third engine drives its corresponding dynamo by means of ropes at 550 revolutions. Each dynamo has an output of 300 amperes at 110 volts pressure.

From the dynamo terminals the main conductors pass to a distributing board, which is so arranged that any one, any two, or all three sets of machines can feed any one circuit. Whatever arrangement is adopted, it is determined by the "checks" in the piece in such a manner that any sudden change in the load due to dark scenes, etc., is at once divided between the second or third dynamo if the individual one from which it is being operated varies beyond a certain limit. The number of circuits is 45, and each stage section is subdivided into three at the colour board, where are united the three different colours in which the stage is connected. A suitable checking board and resistances are erected against the colour board, the resistances being of a new type. There are several new features in this installation, especially as regards a new type of batten and separate method of connection, but particulars of these are not at present forthcoming. The installation is in successful operation, and when completed will comprise incandescent lamps equivalent to 1,750 lights of 16 c.p., but actually varying from 16 c.p. to 50 c.p. The installation has been put up by Mr. Harry South, of Garrick-street, Covent Garden, W.C., and the lighting is very effective and satisfactory.

THE

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All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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IMPORTANT NOTICE.

We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

CHRISTMAS WEEK.

The "Electrical Engineer" will be published on WEDNESDAY next instead of Friday. All Advertisements intended for this issue should be at the Office by midday on TUESDAY.

THE CITY OF LONDON.

At length the reproach is to be removed—that the City of London, the wealthiest city in the world, is the worst lighted of all the great centres of civilisation. The dull yellow gas flicker is to give place to its rival illuminant, and progress may be reported just as history reports the step from rushlights to oil lamps and from oil lamps to gas. It may be a far cry yet to the next step, but it needs little knowledge to foresee it. Replace gas with the electric light, give more and more of it, till the streets do not represent darkness illuminated, but rather the splendour of the full unclouded moon. We English are a queer folk. Once get an idea into the heads of the general body politic, and it takes thirteen generations of Nasmyth's steam hammer to drive it out. Thus it has been with lighting the streets. Originally the idea was merely to allow the belated and benighted inhabitant to find rather than lose his way. No idea of business, no idea of general locomotion, merely a twinkling signpost; and a twinkling signpost it has remained till now. Let any traveller go from St. Paul's Churchyard to Cannon-street Station any dark winter's evening, and say if the street is lighted. Close the shutters of the shops and warehouses of almost any street in the City, and ask is this called a well-lighted street in a civilised town in the end of the nineteenth century. English street lighting was abominable; in parts it is better, and for this improvement we have to thank electricity. Not that electricity is used, but in that the fright of a few years since caused the gas companies to awaken from their lengthy sleep and show what could be done with gas when enough of it was burned in fairly good burners. However, this awakening has not penetrated into commercial quarters, only into those parts where men do congregate after the work of the day is over and the time of pleasure is in full swing. No doubt the City by night is an unexplored wilderness to most of the busy throng who jostle each other therein by day. The City Fathers are gathered day by day from the four quarters of the country round about, and forget around their own firesides the necessities of the City. Year by year, however, the real night is growing less and less. One class of men go home; another class, the working bees, have to labour early and late, and the traffic in the streets continues till later, so that business may be attended to. Man and animal have long cried for more light, and now they are to have it. Previously two sections of the City have been provided for, and at the last meeting of the Commissioners of Sewers the third and last district was delivered to the Brush Company for lighting by electricity. Perhaps we are too premature to say was delivered over, when the report only was adopted. Still we think the matter now fairly settled, and trust that the Brush Company and Messrs. Laing, Wharton, and Down will not belie the belief that

they intend to carry out the work entrusted to them in such a manner as shall enable Englishmen to point with pride to the lighting of the streets of the City of London.

Sufficient time has not yet elapsed since the acceptance of the contract to know exactly the plans of the contractors, but we may venture to make some suggestions. In each case the area to be lighted is a populous one. At the commencement the amount of private lighting may be small, but if that be properly carried out and no mistakes made, the amount of private lighting will rapidly increase. The first cost may seem out of all proportion to the immediate work to be done, if the system adopted provides from the start for this increase. The City will not tolerate the continued taking up and laying of mains to provide for an increased service. The probable service of a year or two or more in advance must be considered. No doubt electrical engineers with big central station installations confronting them are in a position of some uncertainty. The question of high or low pressure has to be settled, and look where and how we will there is no experience which is so satisfactory as to leave no doubt. Then there is the at present novel point, so far as English practice is concerned, of power distribution looming in the background, which complicates the question of continuous or alternate. If alternate, will the motor really be forthcoming? We see no insuperable reason why it should not, but at present no one can safely say there is a sufficiently good commercial apparatus for our purpose. Further, it seems to us that there is just a little element of trouble to crop up, in that many mains are being laid in the streets without due provision being made for inspection. Experience is not yet so ripe that any firm can safely say no fault will be developed. Faults will come in the most unlikely quarters, for it is the unexpected that always happens. The City of London is not like other towns—it may be termed the city of fogs, and any system of lighting will have to provide for a continuous demand night and day for many days together. This demand will test the capabilities of any engineer, for it indicates large fluctuations in the demand. In summer the greater part of the machinery may be idle, in winter there may not be a single horse-power of reserve, however carefully the calculations may have been made. Between these two extremes the engineer sits, his problem being to never allow a failure, never to shirk a demand, and yet to make the installation pay. The work undertaken by these two well-known and eminently capable firms will be watched with the closest care, as the difficulties to be encountered are of no common order, and success, though never for a moment doubted, will be received by all their colleagues with enthusiasm. There is a large amount of electrical work being carried out in the metropolitan area, but none probably will excite more interest than that in the City itself. At the close of 1890 every electrical engineer says, Go ahead and prosper.

SECRET SOLUTIONS.

Of primary batteries, as of books, it may be said, Of the making of them there is no end, and much study of them is certainly a weariness to the flesh. There is no intention of being flippant in making this parody; it, unfortunately, is too true. The only object of primary battery inventors is, or rather it can only be, to extract gold from the pockets of the unwary. The antics of possessors of primary battery patents are very much on a par with those of children who play at "open your mouth and shut your eyes." The recipient of the unseen mouthful does not always rejoice; its composition is a secret; its taste not agreeable, and it is so with these primary batteries—they are usually old friends with a "secret solution." Can anyone point to a single case of one of these "secret solution" batteries having been commercially successful? We know of none, except, as above stated, being successful in extracting gold from fools' pockets. Another battery, with a "secret solution," was brought before the "Inventors' Institute" on Wednesday last. An abstract of what was said is given elsewhere. The practical man's first questions are, What is burnt? and, How is it burnt? As soon as these questions are answered he is in a position to come to some conclusion, more or less correct, as to the value of the battery. According to what can be gathered from hearing the description and seeing the exhibits, it seems that zinc is burnt, the secret fluid containing the active ingredient. Another peculiarity of all these batteries is the ease with which testimonials are obtained. If, indeed, testimonials form any real criteria of value, the miner would long since have had all that heart or eye could desire in the shape of portable electric lamps.

CORRESPONDENCE.

ELECTRIC CRANES.

To the Editor of The Electrical Engineer.

Sir,—In reply to Mr. R. Bolton, in your issue of the 12th inst., *re* "Electric Cranes," will you allow me to say that they consist of one Scotch derrick and three fixed wharf cranes.

I do not "make a merit of reversing the motor to lower the load," but after a careful study of not only the crane and motor, but the men to drive them, the work to do, and the goods to be handled, I accepted it as a necessity, and I am still of opinion that it is the best under the circumstances.

I much regret that by some misunderstanding the motors were described as geared direct to tooth wheels. The power is transmitted by link-leather belting.

Mr. Bolton mentions a steam crane, worked by a boy, unloading mud. Your readers will, I am sure, understand

that there are other things besides mud to be handled, and that speed in hoisting is a secondary consideration when the loads consist of valuable marble, glass, earthenware, and the thousand and one different sizes and forms of goods landed by a carrying company.

As a sample of speed, I may say I shall have working, before the end of the year, two hoists running at 120ft. per minute; but for soft goods only.

He also says "it is not safe to assume that one or at least two cranes will be at work at one time," and that "two-thirds was the proper figure." I assume nothing of the sort, and have provided three-fourths.

The figure of £5 for fuel was for driving the cranes when fitted with steam gear.

He regrets that among electricians great ignorance prevails on the duties of hoisting machinery—a regret I to a great extent share with him, but I am pleased to think it does not apply to me, as I am only an engineer.

The sample given by him of an offer of a 1½-ton crane to make 30 lifts per minute, and which he admits may have been "per hour," is not equally wrong that way; 30 lifts per hour for general work is quite sufficient. It is impossible to sling damageable goods, hoist, and get them stowed on wharf or in boats in less than two minutes per hoist (average).

He says, "there is nothing to be gained to the cause we have at heart by disparaging unduly the opposing force, steam." There is less to be gained by disparaging the work of others of whom we know nothing except that they are trade rivals.—Yours, etc.,

WILLIAM D. SANDWELL.

Victor Works, Holloway.

THE TELEPHONE QUESTION.

Two of our evening contemporaries have been obtaining information on this subject, and we reprint extracts from what they have to say, which is chiefly from the point of view of the companies.

The *Pall Mall Gazette* says: "While we have no love for monopolies, and believe that the public may derive advantages from the introduction of competition, it is right to point out that there are barriers in the way of a perfect telephone service which fresh licenses will not overcome. The desire of the Post Office—in one sense a very proper one—to safeguard the telegraphic rights of the nation has stood in the way of several developments in the telephone service which we have from time to time suggested and urged. The Telegraph Department forbid everything but oral messages, and so a subscriber cannot have a message taken down and delivered. Suggestions have been made for the introduction of the telephone into telegraph offices so that messages might be re-transmitted by telegraph, but the proposed charges have been prohibitory. Then, as to the mechanical difficulties, while gas, water, electric light, and even hydraulic companies have statutory powers to open up the streets and lay mains, the telephone companies have no such right. This is not a mere theoretical difficulty, as the National Company has, as a matter of experience, been prevented from laying underground wires by unenlightened vestry obstruction. In the matter of overhead wires they are equally handicapped, for an obstructive owner can, and often does, prevent a wire being carried over his premises, although it does not come in contact with them. These are practical difficulties which stand in the way of the service in London being so satisfactory as it might be, and until a reasonable amount of power is given by statute we shall not have the full advantage of the telephone.

"With respect to the charges for the use of the telephone, provincial towns are to have the advantage of a reduction from the beginning of the New Year, and a zone system is to be introduced by which those who only desire a half-mile radius can have a service for a less sum. The rates will vary from £8 to £10 per annum. In the case of London the £20 charge is to be maintained, and the reason given when we made an enquiry on the subject is this, that the metropolitan service is most expensive to work. The exchanges have to be multiplied in London quite out of proportion to a city of moderate size, and the ratio of expenses rises instead of falls when the subscribers increase above a certain number. The policy of the company is to spend money on improving the service rather than reducing the charge, and on that line they will face any possible competition. Correspondents have drawn comparisons between the rent charged in London and in other towns, and it will be asked why a business man in London should pay double what the renter of a telephone in, say, Manchester is charged; but in fairness to the company it must be admitted that the conditions of the metropolis are vastly different, and that a much larger outlay is necessary. When a comparison is made with Paris or New York, where the conditions more assimilate, it is London that has the advantage. To many, a saving of £5 is of no consequence, and they would much rather have the money spent in improving the service, and that, no doubt, is the conclusion which the board has drawn; but if competitors enter the field they are sure to aim at cheapness, and a 25 or 30 per cent. reduction will attract many subscribers. The National Company or its progenitors have made a big pile out of the telephone—most holders of successful patents do so, so they need not be railed at on that account as specially mercenary—but the time has now come for them, in their own as well as the public interest, to give as cheap a service as is consistent with efficiency.

The *St. James's Gazette*, in giving a description of how a telephone exchange is worked, says: "The usefulness of the telephone depends upon every subscriber being able to converse with every other. This is managed by leading the single wire into a single room, called the switchroom or exchange, where they can be connected with each other. In the early days of the telephone it was found that difficulties soon arose when the wires became numerous—that is, more than 200. It was impossible to work them all in one room on the plan then in use, so each district had to be provided with its own exchange, which was placed in communication with the others by means of a central one. The National Telephone Company has now in London about 6,000 subscribers and 20 exchanges, all connected with the central exchange in Cannon-street. Some five years ago an improved method of connecting wires was introduced, by means of which a far larger number can be manipulated. This method is called the multiple switchboard, and is capable of working 8,000 wires in a single switchroom. The result of this is that the number of district exchanges is being gradually reduced by the consolidation of several into one, and the aim of the company is to eventually consolidate all the exchanges into two or three.

"The lines running from the district exchanges to the central are called 'trunk lines.' From 20 to 40 wires are bound together, and constitute those formidable-looking cables one sees overhead. To realise the appalling number of wires covering London one should see them from the roof. They form a complete network; the air is thick with them. Sets of half a dozen cables run out together in various directions, rising and falling over the roofs, so as to look exactly like a switchback railway, while the single wires cross hither and thither in hundreds. The question of putting them underground is not one of will, but of power. For several reasons the company would gladly lay the trunk lines, at least, underground; but they have no statutory powers and are opposed by the vestries and the Post Office.

"Communication with Brighton has existed for some years; but within the last three weeks wires have been opened to Birmingham and Manchester. It is intended eventually to reach Glasgow through Preston and Carlisle, and Edinburgh through Newcastle and Galashiels. The expense of laying a line increases in a sort of geometrical ratio to the length; for the longer the line the thicker the wire must be. Thus, one five miles long may cost £20 a mile, while one 100 miles long will cost £75 a mile. For long lines copper is used; for short ones bronze is now preferred. Through the Birmingham and Manchester wires one hears admirably—far better than through our London ones, which are often very unsatisfactory. It is commonly said that after trying for a time with 'Are you there?' and 'I can't hear what you say,' you take a cab and go round.

The reason for this is that the wires, being in bundles close together, act upon each by induction. A given wire picks up fragments of conversation from its fellow *en route*. In the long-distance wires this is obviated by laying two, called a 'loop,' in such a relation to each other that the induction is neutralised. The same plan would be practicable in towns if the wires were laid underground, and thus not only would a danger be removed, but more efficient working secured. But here again the absence of statutory powers, and the difficulty of obtaining either underground or overhead way-leaves, prevents the company from adopting this and other improvements which would be of great advantage to the public.'

ELECTRIC LIGHTING IN LONDON.

The following correspondence appeared in the *Times* of Monday last.

Sir,—On behalf of my company may I ask you to kindly publish this letter in reply to Mr. Richard Chamberlain's very unfair attack upon the company in the House of Commons on the 9th inst., an attack which Sir Michael Hicks-Beach's reply showed was based by Mr. Chamberlain on complete ignorance of facts. Mr. Chamberlain's question was whether the attention of the President of the Board of Trade had been "called to a long-continued default of the Chelsea Electric Supply Company to furnish the statutory current of 100 volts, and to the serious loss of illuminating power sustained by consumers in consequence," and he finished up his questions by also asking whether the Board of Trade would take steps to compel the company "to keep faith with the public or forfeit their concession." Now on behalf of my company I have to state specifically:

1. The Chelsea Company has not failed to keep faith with the public.

2. The pressure for this year has averaged over 100 volts (the statutory standard), but the regulations of the Board of Trade necessarily and specifically allow a variation of pressure of 4 per cent. above and below 100 volts—a variation, I may add, which of necessity takes place, and which is imperceptible to the consumer without the use of delicate instruments.

3. There has never been a failure of light and hardly any complaints (except from Mr. R. Chamberlain) have been received from customers, and those few were remedied at once. Why Mr. R. Chamberlain should use his position as a member of Parliament to the detriment of a trading concern, honestly doing its best, I am at a loss to understand, and if his remarks were made outside instead of inside the assembly they were addressed to, he would be brought to account for them. It is true my company has not used Messrs. Chamberlain and Hookham's meter, but Mr. R. Chamberlain, I believe, possesses a "voltmeter," and, being a gentleman of leisure, he studies this instrument with a view to pouncing on the company if they fall below the statutory pressure, he being ignorant of the standard. Whatever Mr. R. Chamberlain's motives may be, my board protest most emphatically against his attack (based upon an absolutely erroneous view of the statutory rights and obligations) upon a company which has not broken faith with the public, but which has, under great difficulties, successfully given a good and constant supply of electric light to a large and important district—a supply, I believe, more perfect than any other in the United Kingdom.—I am, Sir, your obedient servant,

J. Irving Courtenay, Chairman,
Chelsea Electricity Supply Company, Limited.
Draycott-place, Sloane-square, S.W.,
December 10.

Sir,—Messrs. Mappin are not the only people who have reason to complain of the default in electric lighting companies. In this district we have the misfortune to be supplied by the Chelsea Electricity Supply Company, Limited, and this company's record for more than 12 months has been one of continued broken promises and shuffling excuses. They undertake to supply current of 100 volts, and for this they duly charge. What they do supply during the principal lighting hours, notwithstanding repeated complaints, is current of a pressure of 96 or 98 volts only. As the lamps are calculated for the higher pressure, we are left in a state of semi-darkness. They appear to be unable to keep faith with their customers, and it will not be until another company comes into this exceptionally favourable area that the houses in the district are likely to be efficiently lighted.

Meantime, I am putting a question to the President of the Board of Trade on the subject, in the hope of securing some safeguards.—I am, yours faithfully,

Richard Chamberlain.
39, Cadogan-square, S.W., Dec. 8.

Sir,—Referring to Messrs. Mappin Brothers' letter in the *Times* of to-day, we write to confirm the apparent inability of the London Electric Supply Corporation, Limited, to carry out their contract with clients, not merely as regards the present total failure, which may or may not be capable of reasonable explanation, but from a long and exasperating experience of more or less partial or total failures, extending over the whole period of our connection with the London Electric Supply Corporation, Limited.

The systematic reply of the corporation is that, as the current is supplied by meter, the consumer suffers no loss and has no ground for claiming consequential damage; but surely, when Parliament vested such special powers in a public company, it could not have foreseen the despotic power such a company would possess, to the unalloyed detriment of their consumers and the general public.

We may add that one theory we may put forward to explain the breakdown in the lightiug system of the London Electric Supply Corporation, Limited, has been the too great anxiety of the corporation at the outset to secure more consumers for their current than the powers of their plant warranted. This suggestion is supported by reference to the manner in which the light for months past has disappeared and reappeared at fitful intervals, as it seems to prove the necessity on the part of the corporation to husband their current at the inconvenience of their consumers, for at certain times when the corporation were duly supplying X, Y, and Z the current was cut off from A, B, and C, and *vice versâ*.

Could any remedy for this disappointing state of things be suggested, we believe it would be hailed as a public boon.—We are, Sir, your obedient servants,

Liberty and Co.
Regent-street, W., Dec. 8.

Sir,—I have seen Messrs. Mappin's letter in your to-day's issue. It strikes me as unfair to the other electric lighting companies. I depend for my light on a public supply company, and my experience of its service is diametrically opposite to that of Messrs. Mappin. I have no financial interest in any of the electric light supply companies and have no experience of the company to which Messrs. Mappin refer, but I think it only fair to the public electric supply company from which I am drawing my electricity, to point out that Messrs. Mappin Brothers are not right in their conclusion as to the "utter incapacity" of all public electric lighting companies. My experience has been an extremely pleasant one. My house was connected to the public supply of the House-to-House Electric Supply Company, at Kensington, nearly a year since, and from then to now there has not been one single failure in the lighting, and the steadiness of the lights has elicited the praise from time to time of all my visitors and friends.

I understand that the reason why the House-to-House Supply is so reliable is that there is always lying idle and in reserve at their works spare plant, ready whenever it appears necessary to be switched on to relieve plant in work, which might otherwise fail in giving the light up to the standard for which the House-to-House Company is now justly obtaining so good a reputation.—I am, Sir, your obedient servant,
Onslow-Gardens.
December 8.

Sir,—I notice in your columns of the 6th inst. a letter from Messrs. Mappin Bros., 220, Regent-street, warning the public against the utter incapacity of electric light com-

panies, as they have been unfortunate in their supply from the London Electric Supply Corporation.

It may interest your readers to know that this hotel has been supplied with electric light from the House-to-House Electric Supply central station in the Richmond-road (about a mile distant from any hotel), for nearly 12 months, and it has never yet failed, there being as many as the equivalent of 1,350 8-c.p. lamps entirely under the control of the operator.

I should feel obliged if you would kindly insert this, as it would be unfair for such a letter as Messrs. Mappin Bros.' to prejudice all electric light supply companies.—I remain, Sir, your obedient servant, JAMES BAILEY,

Bailey's Hotel, Gloucester-road, London,
December 10.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E

LECTURE III.

(*Continued from page 532.*)

ELECTROMAGNETS FOR USE WITH ALTERNATING CURRENTS.

When you are designing electromagnets for use with alternating currents, it is necessary to make a change in one respect, namely, you must so laminate the iron that internal eddy currents shall not occur; indeed, for all rapid acting electromagnetic apparatus it is a good rule that the iron must not be solid. It is not usual with telegraphic instruments to laminate them by making up the core of bundles of iron plates or wires, but they are often made with tubular cores—that is to say, the cylindrical iron core is drilled with a hole down the middle, and the tube so formed is slit with a sawcut to prevent the circulation of currents in the stance of the tube. Now, when electromagnets are to be employed with rapidly alternating currents, such as are used for electric lighting, the frequency of the alternations being usually about 100 periods per second, slitting the cores is insufficient to guard against eddy currents; nothing short of completely laminating the cores is a satisfactory remedy. I have here, thanks to the Brush Electric Engineering Company, an electromagnet of the special form that is used in the Brush arc lamp when required for the purpose of working in an alternating-current circuit. It has two bobbins that are screwed up against the top of an iron box at the head of the lamp. The iron slab serves as a kind of yoke to carry the magnetism across the top. There are no fixed cores in the bobbins, which are entered by the ends of a pair of yoke plungers. Now in the ordinary Brush lamp for use with a steady current, the plungers are simply two round pieces of iron tapped into a common yoke; but for alternate-current working this construction must not be used, and instead a U-shaped double plunger is used, made up of laminated iron, riveted together. Of course it is no novelty to use a laminated core; that device, first used by Joule, and then by Cowper, has been re-patented rather too often during the past 50 years to be considered as a recent invention.

The alternate rapid reversals of the magnetism in the magnetic field of an electromagnet, when excited by alternating electric currents, sets up eddy currents in every piece of undivided metal within range. All frames, bobbin tubes, bobbin ends, and the like must be most carefully slit, otherwise they will overheat. If a domestic flatiron is placed on the top of the poles of a properly laminated electromagnet, supplied with alternating currents, the flatiron is speedily heated up by the eddy currents that are generated internally within it. The eddy currents set up by induction in neighbouring masses of metal, especially in good conducting metals, such as copper, give rise to many curious phenomena. For example, a copper disc or copper ring placed over the pole of a straight electromagnet so excited is violently repelled. These remarkable phenomena have been recently investigated by Prof. Elihu Thomson, with whose beautiful and elaborate researches we have lately been made conversant in the pages of the technical journals. He rightly attributes many of the repulsion phenomena to the lag in phase of the alternating currents thus induced in the conducting metal. The electromagnetic inertia, or self-inductive property of the electric circuit, causes the currents to rise and fall later in time than the E.M.F.'s by which they are occasioned. In all such cases the impedance which the circuit offers is made up of two things—resistance and inductance. Both these causes tend to diminish the amount of current that flows, and the inductance also tends to delay the flow.

ELECTROMAGNETS FOR QUICKEST ACTION.

I have already mentioned Hughes's researches on the form of electromagnet best adapted for rapid signalling. I have also incidentally mentioned the fact that where rapidly varying currents are employed, the strength of the electric current that a given battery can yield is determined not so much by the resistance of the electric circuit, as by its electric inertia. It is not a very easy task to explain precisely what happens to an electric circuit when the current is turned on suddenly. The current does not suddenly rise to its full value, being retarded by inertia. The ordinary law of Ohm in its simple form no longer applies; one needs to apply that other law which bears the name of the law of Helmholtz, the use of which is to give us an expression, not for the final value of the current, but for its value at any short time, t, after the current has been turned on. The strength of the current after a lapse of a short time, t, cannot be calculated by the simple process of taking the E.M.F. and dividing it by the resistance, as you would calculate steady currents.

* Cantor lectures, delivered before the Society of Arts.

In symbols, Helmholtz's law is:

$$i_t = \frac{E}{R}\left(1 - \epsilon^{-\frac{R}{L}t}\right).$$

In this formula i_t means the strength of the current after the lapse of a short time, t; E is the E.M.F.; R the resistance of the whole circuit; L its coefficient of self-induction; and ϵ the number 2·7183, which is the base of the Napierian logarithms. Let us look at this formula. In its general form it resembles Ohm's law, but with a new factor—namely, the expression contained within the brackets. This factor is necessarily a fractional quantity, for it consists of unity less a certain negative exponential, which we will presently further consider. If the factor within brackets is a quantity less than unity, this signifies that i_t will be less than E÷R. Now, the exponential of negative sign, and with negative fractional index, is rather a troublesome thing to deal with in a popular lecture. Our best way is to calculate some values, and then plot it out as a curve. When once you have got the form of a curve, you can begin to think about it, for the curve gives you a mental picture of the facts that the long formula expresses in the abstract. Accordingly we will take the following case. Let E=10 volts; R=1 ohm; and let us take a relatively large self-induction, so as to exaggerate the effect; say let L=10 quads. This gives us the following:

t (sec.)	$\epsilon^{+\frac{R}{L}t}$	i_t
0	1	0
1	1·105	0·950
2	1·221	1·810
5	1·649	3·936
10	2·718	6·343
20	7·389	8·646
30	20·08	9·501
60	403·4	9·975
120	162800·0	9·999

In this case the value of the steady current, as calculated by Ohm's law, is 10 amperes; but Helmholtz's law shows us that with the great self-induction which we have assumed to be present, the current, even at the end of 30 seconds, has only risen up to within 95 per cent. of its final value; and only at the end of two minutes has practically attained full strength. These values are set out in the highest curve in Fig. 54, in which, however, the

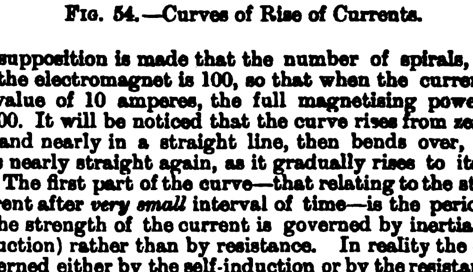


FIG. 54.—Curves of Rise of Currents.

further supposition is made that the number of spirals, S, in the coils of the electromagnet is 100, so that when the current attains its full value of 10 amperes, the full magnetising power will be S i=1,000. It will be noticed that the curve rises from zero at first steeply and nearly in a straight line, then bends over, and then becomes nearly straight again, as it gradually rises to its limiting value. The first part of the curve—that relating to the strength of the current after *very small* interval of time—is the period within which the strength of the current is governed by inertia (*i.e.*, the self-induction) rather than by resistance. In reality the current is not governed either by the self-induction or by the resistance alone, but by the ratio of the two. This ratio is sometimes called the "time-constant" of the circuit, for it represents *the time* which the current takes in that circuit to rise to a definite fraction of its final value. This definite fraction is the fraction $\frac{\epsilon - 1}{\epsilon}$; or in decimals, 0·634. All curves of rise of current are alike in general shape—they differ only in scale; that is to say, they differ only in the height to which they will ultimately rise, and in the time they will take to attain this fraction of their final value.

Example 1.—Suppose E = 10; R = 400 ohms; L = 8. The final value of the current will be 0·025 ampere, or 25 milliamperes. Then the time-constant will be 8 ÷ 400 = $\frac{1}{50}$th sec.

Example 2.—The P.O. standard "A" relay has R = 400 ohms; L = 3·25. It works with 0·5 milliampere current, and therefore will work with five Daniell cells through a line of 9,600 ohms. Under these circumstances, the time-constant of the instrument on short circuit is 0·0081 sec.

It will be noted that the time-constant of a circuit can be reduced

either by diminishing the self-induction or by increasing the resistance. In Fig. 54 the position of the time-constant for the top curve is shown by the vertical dotted line at 10 seconds. The current will take 10 seconds to rise to 0·634 of its final value. This retardation of the rise of current is simply due to the presence of coils and electromagnets in the circuit; the current as it grows being retarded because it has to create magnetic fields in these coils, and so sets up opposing E.M.F. that prevent it from growing all at once to its full strength. Many electricians, unacquainted with Helmholtz's law, have been in the habit of accounting for this by saying that there is a lag in the iron of the electromagnet cores. They tell you that an iron core cannot be magnetised suddenly; that it takes time to acquire its magnetism. They think it is one of the properties of iron. But we know that the only true time-lag in the magnetisation of iron—that which is properly termed "viscous hysteresis"—does not amount to any great percentage of the whole amount of magnetisation, takes comparatively a long time to show itself, and cannot therefore be the cause of the retardation which we are considering. There are also electricians who will tell you that when magnetisation is suddenly evoked in an iron bar, there are induction currents set up in the iron which oppose and delay its magnetisation. That they oppose the magnetisation is perfectly true; but if you carefully laminate the iron so as to eliminate eddy currents, you will find, strangely enough, that the magnetism rises still more slowly to its final value. For by laminating the iron you have virtually increased the self-inductive action, and increased the time-constant of the circuit, so that the currents rise more slowly than before. The lag is not in the iron, but in the magnetising current, and the current being retarded, the magnetisation is, of course, retarded also.

Connecting Coils for Quickest Action.

Now let us apply these most important, though rather intricate, considerations to the practical problems of the quick working of the electromagnet. Take the case of an electromagnet forming some part of the receiving apparatus of a telegraph system which it is desired to secure very rapid working. Suppose the two coils that are wound upon the horseshoe core are connected together in series. The coefficient of self-induction for these two is four times as great as that of either separately; coefficients of self-induction being proportional to the square of the number of turns of wire that surround a given core. Now, if the two coils, instead of being put in series, are put in parallel, the coefficient of self-induction will be reduced to the same value as if there were only one coil, because half the line current (which is practically unaltered) will go through each coil. Hence the time-constant of the circuit when the coils are in parallel will be a quarter of that which it is when the coils are in series; on the other hand, for a given line-current, the final magnetising power of the two coils in parallel is only half what it would be with the coil in series. The two lower curves in Fig. 54 illustrate this, from which it is at once plain that the magnetising power for very brief currents is greater when the two coils are put in parallel with one another than when joined in series.

Now this circumstance has been known for some time to telegraph engineers. It has been patented several times over. It has formed the theme of scientific papers, which have been read both in France and in England. The explanation generally given of the advantage of uniting the coils in parallel is, I think, fallacious; namely, that the "extra currents"—*i.e.*, currents due to self-induction—set up in the two coils are induced in such directions as tend to help one another when the coils are in series, and to neutralise one another when they are in parallel. It is a fallacy, because in neither case do they neutralise one another. Whichever way the current flows to make the magnetism, it is opposed in the coils while the current is rising, and helped in the coils while the current is falling, by the so-called extra currents. If the current is rising in both coils at the same moment, then, whether the coils are in series or in parallel, the effect of self-induction is to retard the rise of the current. The advantage of parallel grouping is simply that it reduces the time-constant.

Battery Grouping for Quickest Action.

One may consider the question of grouping the battery cells from the same point of view. How does the need for rapid working, and the question of time-constant, affect the best mode of grouping the battery cells? The amateur's rule, which tells you to so arrange your battery that its internal resistance should be equal to the external resistance, gives you a result wholly wrong for rapid working. The supposed best arrangement will not give you (at the expense even of economy) the best result that might be got out of the given number of cells. Let us take an example and calculate it out, and place the results graphically before our eyes in the form of curves. Suppose the line and electromagnet have together a resistance of six ohms, and that we have 24 small Daniell cells, each of E.M.F., say, one volt, and of internal resistance, four ohms. Also let the coefficient of self-induction of the electromagnet and circuit be six quadrants. When all the cells are in series the resistance of the battery will be 96 ohms, the total resistance of the circuit 102 ohms, and the full value of the current 0·235 ampere. When all the cells are in parallel, the resistance of the battery will be 0·133 ohm, the total resistance 6·133 ohms, and the full value of the current 0·162 ampere. According to the amateur rule of grouping cells, so that internal resistance equals external, we must arrange the cells in four parallels, each having six cells in series, so that the internal resistance of the battery will be six ohms, total resistance of circuit 12 ohms, full value of current 0·5 ampere. Now the corresponding time-constant of the circuit in the three cases (calculated by dividing the coefficient of self-induction by the total resistance) will be respectively—in series, 0·06 sec.; in parallel, 0·96 sec.; grouped for maximum steady current, 0·5 sec. From these data we may now draw the three curves, as in Fig. 55, wherein the abscissæ are the values of time in seconds, and the ordinates the current. The faint vertical doted lines mark the time-constants in the three cases. It will be seen that when rapid working is required the magnetising current will rise, during short intervals of time, more rapidly if all the cells are put in series than it will do if the cells are grouped according to the amateur rule.

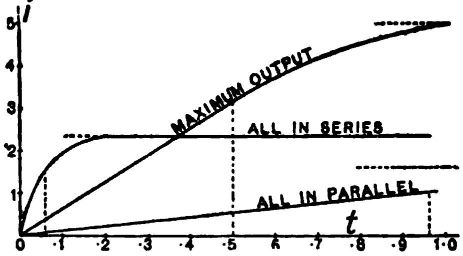


Fig. 55.—Curves of Rise of Current with Different Groupings of Battery.

When they are all put in series, so that the battery has a much greater resistance than the rest of the circuit, the current rises much more rapidly, because of the smallness of the time-constant, although it never attains the same ultimate maximum as when grouped in the other way. That is to say, if there is self-induction as well as resistance in the circuit, the amateur rule does not tell you the best way of arranging the battery. There is another mode of regarding the matter which is helpful. Self-induction, while the current is growing, acts as if there were a sort of spurious addition to the resistance of the circuit; and while the current is dying away it acts of course in the other way, as if there were a subtraction from the resistance. Therefore, you ought to arrange the battery so that the internal resistance is equal to the real resistance of the circuit, plus the spurious resistance during that time. But how much is the spurious resistance during that time? It is a resistance proportional to the time that has elapsed since the current was turned on. So then it comes to a question of the length of time for which you want to work it. What fraction of a second do you require your signal to be given in? What is the rate of the vibrator of your electric bell? Suppose you have settled that point, and that the short time during which the current is required to rise is called t, then the apparent resistance at time t after the current is turned on is given by the formula:

$$R_t = R \times e^{\frac{R}{L}t} \div \left(e^{\frac{R}{L}} - 1\right).$$

Time-constants of Electromagnets.

I may here refer to some determinations made by M. Vaschy respecting the coefficients of self-induction of the electromagnets of a number of pieces of telegraphic apparatus. Of these I must only quote one result, which is very significant; it relates to the electromagnet of a Morse receiver of the pattern habitually used on the French telegraph lines:

	L, in quadrants.
Bobbins, separately, without iron cores	0·233 and 0·265.
Bobbins, separately, with iron cores	1·65 and 1·71.
Bobbins, with cores joined by yoke, coils in series..	6·37.
Bobbins, with armature resting on poles......	10·68.

It is interesting to note how the perfecting of the magnetic circuit increases the self-induction.

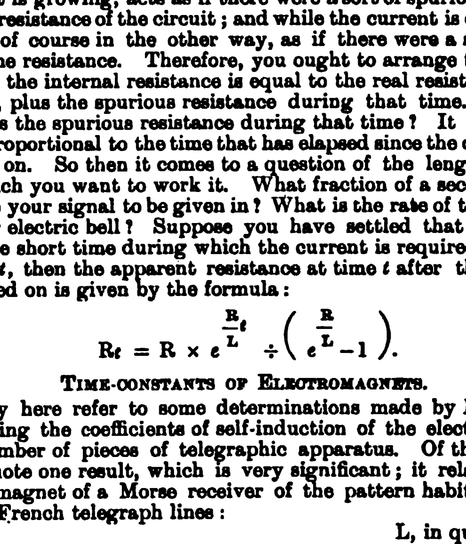


Fig. 56.—Electromagnets of Relay and their Effects.

Thanks to the kindness of Mr. Preece, I have been furnished with some most valuable information about the coefficients of self-induction, and the resistance of the standard pattern of relays, and other instruments which are used in the British postal telegraph service, from which data one is able to say exactly what the time-constants of those instruments will be on a given circuit, and how long in their case the current will take to rise to any given fraction of its final value. Here let me refer to a very capital paper by Mr. Preece in an old number of the *Journal* of the Society of Telegraph Engineers, a paper "On Shunts," in which he treats this question, not as perfectly at it could now be treated with the fuller knowledge we have in 1890 about the coefficients of self-induction, but in a very useful and practical way. He showed most completely that the more perfect the magnetic circuit is, though, of course, you are getting more magnetism from your current, the more is that current retarded. Mr. Preece's mode of experiment was extremely simple; he observed the throw of the galvano-

meter when the circuit which contained the battery and the electromagnet was opened by a key which at the same moment connected the electromagnet wires to the galvanometer. The throw of the galvanometer was assumed to represent the extra current which flowed out. Fig. 56 represents a few of the results of Mr. Preece's paper. Take from an ordinary relay a coil, with its iron core, half the electromagnet, so to speak, without any yoke or armature. Connect it up as described, and observe the throw given to the galvanometer. The amount of throw obtained from the single coil was taken as unity, and all others were compared with it. If you join up two such coils, as they are usually joined, in series, but without any iron yoke across the cores, the throw was 17. Putting the iron yoke across the cores, to constitute a horseshoe form, 496 was the throw—that is to say, the tendency of this electromagnet to retard the current was 496 times as great as that of the simple coil. But when an armature was put over the top the effect ran up to 2,238. By the mere device of putting the coils in parallel, instead of in series, the 2,238 came down to 502, a little less than the quarter value which would have been expected. Lastly, when the armature and yoke were both of them split in the middle, as is done in fact in all the standard patterns of the British Postal Telegraph relays, the throw of the galvanometer was brought down from 502 to 26. Relays so constructed will work excessively rapidly. Mr. Preece states that with the old pattern of relay having so much self-induction as to give a galvanometer throw of 1,688, the speed of signalling was only from 50 to 60 words per minute; whereas, with the standard relays constructed on the new plan, the speed of signalling is from 400 to 450 words per minute. It is a very interesting and beautiful result to arrive at from the experimental study of these magnetic circuits.

SHORT CORES *versus* LONG CORES.

In considering the forms that are best for rapid action, it ought to be mentioned that the effects of hysteresis in retarding changes in the magnetisation of iron cores are much more noticeable in the case of nearly closed magnetic circuits than in short pieces. Electromagnets with iron armatures in contact across their poles will retain, after the current has been cut off, a very large part of their magnetism, even if the cores be of the softest of iron; but so soon as the armature is wrenched off the magnetism disappears. An air gap in a magnetic circuit always tends to hasten demagnetising. A magnetic circuit composed of a long air path and a short iron path demagnetises itself much more rapidly than one composed of a short air path and a long iron path. In long pieces of iron the mutual action of the various parts tends to keep in them any magnetisation that they may possess; hence they are less readily demagnetised. In short pieces, where these mutual actions are feeble or almost absent, the magnetisation is less stable, and disappears almost instantly on the cessation of the magnetising forces. Short bits and small spheres of iron have no "magnetic memory." Hence the cause of the commonly received opinion amongst telegraph engineers that for rapid work electromagnets must have short cores. As we have seen, the only reason for employing long cores is to afford the requisite length for winding the wire which is necessary for carrying the needful circulation of current to force the magnetism across the air gaps. If for the sake of rapidity of action, length has to be sacrificed, then the coils must be heaped up more thickly on the short cores. The electromagnets in American patterns of telegraphic apparatus usually have shorter cores, and a relatively greater thickness of winding upon them, than those of European patterns.

ELECTRIC LIGHTING PROGRESS IN LONDON.*

BY F. BAILEY, A.M.I.C.E.

(*Continued from page 530.*)

ST. JAMES'S AND PALL MALL ELECTRIC LIGHTING COMPANY.

This company was formed for the purpose of supplying the whole of the parish of St. James, Westminster, and commenced to supply current under their provisional orders from their station in Mason's-yard, Duke-street, on April 4th, 1889.

The direct current is employed without batteries.

At present the above station supplies the southern half of the district, the total plant consisting of five Davey-Paxman boilers, working at 150lb. per square inch. Two large Berryman feed-water heaters. Ten Willans compound engines, each of 200 i.h.p. Two Willans compound engines, each of 70 i.h.p. Twelve dynamos, Latimer Clark, Muirhead, and Co., and Siemens, driven direct from the engines. The whole of this plant is neatly arranged, so as to occupy the least space.

The mains consist of a network of conductors on the three-wire system, supplied at about 100 volts at the station by suitable feeders. A cast-iron trough or culvert is laid under the surface of the pavement, and three conductors, each consisting of a number of strips of bare copper, which can be added to at any time, are carried by porcelain bridges, placed at suitable intervals apart. To avoid any risk of the mains touching each other, porcelain distance-pieces are placed over the mains. A cast-iron lid, with water-tight joint, covers the trough. Connection to customers' houses is made by drawing well-insulated cable through gas tubing, which is screwed into the trough.

* Paper read before the Society of Arts on Wednesday, Dec. 10.

On December 5 a total equivalent to 23,174 lamps of 8 c.p. were connected. Mr. Dobson, the company's engineer, kindly informed me that the maximum lamp supply is equal to about 13,222 lamps of 6 c.p.—say 57 per cent.

THE WESTMINSTER ELECTRIC SUPPLY CORPORATION, LIMITED.

The district in which this corporation is authorised to supply electricity by its provisional order, comprises that portion of the united parishes of St. Margaret and St. John, Westminster, which lies to the south of the centre line of the Metropolitan District Railway, and the portion of the parish of St. George, Hanover-square, covering Belgravia and Mayfair.

The system adopted is similar to that of the Kensington and Knightsbridge Company, direct current in conjunction with batteries used as regulators, and also for supply during hours of minimum demand.

Three stations are being erected, one at Millbank-street, one at Eccleston-place, and one in Davis-street, in the positions shown on the map.

Current is now being supplied from the Millbank-street station and from a small temporary station in Dacre-street. The other two are being pushed forward as fast as possible, in order to supply from all stations early in the year.

Mains are being laid for a three-wire distribution, Messrs. Crompton being the contractors for the Westminster district, where the system adopted is similar to that put down by Mr. Crompton for the Kensington and Knightsbridge Company.

For other parts of the district Prof. Kennedy, the engineer to the company, has devised the arrangement shown on the plan. Bare copper strip rests on stoneware insulators placed from 6ft. to 8ft. apart, and bedded in the concrete culvert as shown. The copper is stretched by a special tool before being pulled in, and this process gives it sufficient stiffness not to sag perceptibly between the insulators. The total sectional area of the conductors can be increased when required by the addition of more copper strip. Feeders are used in a most systematic manner, and Prof. Kennedy is to be congratulated on the favourable prospects of this company's work. There is a large demand for light in the district, and the rapid progress of this company justifies the expectation of a speedy supply from the stations now in progress.

THE LONDON ELECTRIC SUPPLY CORPORATION, LIMITED.

The parliamentary powers possessed by this company cover a large area, comprising the district bordering the south side of the Thames from Westminster Bridge to Greenwich, Mayfair, Belgravia, St. James and Pall-mall, St. Martin's-in-the-Fields, part of Westminster, Chelsea, and two isolated areas—namely, Newington and Clerkenwell.

The Ferranti system is employed throughout, alternating current being generated at an extra high pressure and transmitted to converting stations, from which it is distributed at high pressure to the service converters.

The corporation has erected a large station at Deptford, which has been admirably designed for the purpose, having road-frontage, wharfage, and coaling dock. The plant consists of 24 Babcock and Wilcox boilers, four compound vertical engines by Hick and Hargreaves, two of which are 1,500 i.h.p. each, and two of 750 i.h.p. each. There is almost unlimited room for extension.

Each of these engines drives a Ferranti dynamo by cotton ropes, the exciters being driven direct from independent engines.

In order to convey the high pressure from Deptford to London, Mr. Ferranti devised a special form of main for this purpose, which has been frequently described.

About 28 miles of these mains have been laid, the distributing mains from the converting stations being of various kinds. This company's Grosvenor Gallery station having lately been closed, a hurried change has had to be made in order to enable the corporation to supply from Deptford.

CHELSEA ELECTRICITY SUPPLY COMPANY.

This company's provisional order covers the whole parish of Chelsea, a portion of which the company is now supplying.

Direct current is employed with accumulators, but, unlike other companies in London, in this case the accumulators are charged with a high-pressure current, and discharge direct at low pressure into the mains. I am not in possession of any information of this company's progress. From published descriptions you will doubtless be aware that the generating station is situated at Draycott-place with battery stations at Clabon-mews, Egerton-mews, and Pavilion-road.

THE ELECTRICITY SUPPLY CORPORATION.

This company obtained a provisional order in 1889 for supplying the whole of the parish of St. Martin's-in-the-Fields. Direct current, without batteries. The station is placed just off the Strand, and was laid down some years ago by Messrs. Gatti to supply the Adelaide Gallery and the Adelphi Theatre; it is now being extended. At present the plant consists of four Babcock and Wilcox boilers; five Willans engines, amounting

to 600 i.h.p.; five Edison-Hopkinson dynamos, each being driven direct from one engine. Callender mains are laid down in Callender-Webber casing.

St. Pancras Vestry.

The Vestry have decided to carry out the electric lighting of the parish themselves, and have secured the able services of Prof. Robinson as their engineer. The direct-current system will be adopted, and a station is now being erected in Stanhope-street, Euston-road, for the supply of the south-west portion of the parish.

Notting Hill Electric Lighting Company.

The provisional order granted to this company includes the district of Notting Hill which comes within part of the parish of Kensington, St. Mary Abbott.

The system is similar to that adopted by the Kensington and Knightsbridge Company.

The first generating station, situated off High-street, Kensington, is now approaching completion, the plant consisting of Babcock and Wilcox boilers, Willans engines, Crompton dynamos, and Howell batteries; Crompton's mains are also laid, as shown on the map.

The Metropolitan Electric Supply Company.

The parliamentary powers of this company include the large and important districts of Paddington and Marylebone parishes, with part of St. Martin's-in-the-Fields, the Holborn and Strand district, and St. Giles's Board of Works.

Various systems are employed by this company, both the alternating and direct current systems being adopted.

The company is at present supplying from four stations, and it may perhaps be better to describe them separately.

The Whitehall station, situated in Whitehall-avenue, is a direct-current station which possesses no novelty and supplies the surrounding locality, the plant consisting of Hick-Hargreaves boilers, Willans engines, and Siemens dynamos. Callender mains are laid down the Northumberland-avenue subway and elsewhere.

The Sardinia-street station contains a complete plant on the Westinghouse alternating-current system, consisting of 12 Babcock and Wilcox boilers, working at 150lb. per square inch; 12 Westinghouse alternators, each being belt-driven by a Westinghouse compound engine, as shown on the plan. There are also three exciters, each being belt-driven by its own engine.

The Manchester-square station contains nine Babcock and Wilcox boilers, 10 Parker alternators, each driven direct by a 200-h.p. Willans engine, as shown in the sketch of the engine-house placed on the wall. There are also four exciters, each being driven direct by a Willans engine. The steam piping is arranged on a method devised by Mr. J. H. Rosenthal, the London manager of the Babcock and Wilcox Boiler Company, and possesses many advantages.

The Rathbone-place station contains plant of a similar kind, there being five boilers, six alternators and engines, two exciters and engines.

The system of distribution from the three latter alternating current stations is of a simple description—cast-iron pipes laid underground form conduits, into which "Silvertown" vulcanised rubber cables have been drawn when required. Split T-pieces are inserted in the pipes for connection to customers' premises. These mains are looped from house to house, returning to the station, so as to form complete rings. Each customer has, therefore, a duplicate supply, thus enabling new customers to be connected to the system without interrupting the supply on the circuit.

All these three stations are connected together by trunk mains, which enables one station to assist another, or take the whole load of the district during the hours of least demand. The current leaves each of these stations at a pressure of 1,000 volts, this moderate pressure being adopted as the number of supply stations reduces the distance to which each cable has to be laid to meet the demand. The whole supply is distributed by a number of small cables, which can be easily replaced when required.

The demand for light has been very encouraging; and, as you will see from the table, the progress of the lamp connection to these stations has been very rapid. I regret, however, to say that, although this company at present supplies light to 12 public-houses, only four churches are, so far, connected with the system.

Having now completed our tour of the stations of the various companies, we have seen how the streets of London have lately been disturbed in order to lay all these mains; no doubt a certain amount of inconvenience has unavoidably been caused to traffic, but it has revealed the wonderful system of organisation by which London is governed; and the vestry surveyors, whose labours have been much increased, have not only afforded every facility for carrying out the work, but have rapidly reinstated the pavements at, of course, the cost of the respective electric light companies. The public, therefore, though for a short time inconvenienced, have in reality secured new pavements for old.

Summarising the plants adopted by the various supply companies, it is interesting to notice how the peculiar conditions of electrical supply in the very limited space usually available have been provided for by manufacturers. As an instance of this it may be noted that Willans engines, amounting to about 9,000 h.p., are used by the public supply companies in London, and similar engines, aggregating more than 2,000 i.h.p., for private plants in the metropolis. The Babcock and Wilcox boiler, having also been so universally adopted, it may be of interest to state that 78 boilers of this type, supplying 14,230 i.h.p., are now at work in London.

Private Plants.

One result of the Act of 1882 has undoubtedly been to cause a large number of private installations to be erected, but so many of our leading electric light contractors have laid down thoroughly efficient plants that there is perhaps no cause for regret. Most of the large terminal London railway stations work their own electric light machinery, the largest installation being at Paddington, where the Great Western Railway Company have machinery of 1,500 h.p. for the purpose. For residences, gas engines provide the motive power for driving dynamos supplying about 18,000 lamps of 32 watts each, the remainder being steam-driven.

It may be of interest to note that the Crossley Otto gas engine, which was awarded a gold medal at this society's recent motor competition, is now in use for this purpose, having been pressed into service by Messrs. Laing, Wharton, and Down. This total may appear large, but it must be remembered that many of the large hotels having their own steam plant for working lifts, warming, and cooking, have added electric lighting machinery; the total also includes the lamps at D'Oyly Carte's new theatre, where Messrs. Verity have erected a plant so complete that it may almost be considered a small central station.

Number of Incandescent Lamps now in Use in London.

With the kind assistance of the electric light contractors, particularly Messrs. Verity, Laing, Wharton, and Down, Phipps and Dawson, Drake and Gorham, Sharp and Kent, and many others, and the public supply companies, I have been able to collect data that the total equivalent number of 32-watt lamps now in use in London is approximately as follows:

Public supply companies	179,060
Private plants	85,000
Total	264,060

At the present rate of increase a very moderate estimate gives an addition of at least 4,000 lamps per week, and there is little doubt that this number will be greatly exceeded at no distant date.

All these incandescent lamps have been calculated on a basis of 32 watts or 8 c.p. lamps, as experience has shown that this is a size much used in London, and, by taking the smallest lamp, we avoid dealing with half lamps.

Before leaving these particulars, it will probably be of service to the designers of future stations if we tabulate the data collected.

Table Showing Percentage of Maximum Lamp Supply at any Moment to Total Lamp Connection.

Station.	Percentage.
House-to-House	42
Kensington and Knightsbridge	30 to 40
St. James's and Pall-mall	57
Sardinia-street	45
Rathbone-place	64
Manchester-square	45

It may perhaps be of interest if I draw your attention to the following table, based upon data which has come under my observation, showing the candle-power of lamps mostly used:

Lamps (50 volts).

8 c.p	16 c.p.	32 c.p.	50 c.p.	100 c.p.	200 c.p.	500 c.p.
597	1,666	62	13	8	8	3

Lamps (100 volts).

5,437	5,131	176	26	57	40	3

During 1886 and part of 1887 I was able to collect the data (see Table A) of the behaviour of incandescent lamps, each of 25 c.p., with an efficiency of $3\frac{1}{2}$ watts per candle, and I trust that more information of this kind will be collected.

With reference to arc lighting, considerable progress is being made; and, although the number now in use in London does not much exceed 1,000 lamps, there is no doubt that rapid progress will be made.

Prof. Silvanus Thompson, in March, 1889, showed you all the best known arc lamps; and, for further information of their development, I must refer you to his most complete paper on the subject, published in the society's *Journal*, March 8th, 1889.

It is a matter for regret that there is no progress to be noticed in connection with the efficiency of the incandescent lamp, which remains much the same as it was five years ago. It will be apparent from the table showing the candle-power of lamp-

TABLE A.—INCANDESCENT LAMPS.—LIFE, AND NATURE OF FRACTURE.
All Lamps 25 c.p. Brass Collar, Edison-Swan.

Lamps.			Nature of Failure.											
			Glass Globe.						Filament Fractured.					
Volts	No. of lamps renewed.	Average life hours.	Broken.	Per cent.	Blackened.	Per cent.	Plaster.	Per cent.	Loop.	Per cent.	Stem.	Per cent.	Joint.	Per cent.
151	536	[illegible]	114	21·2	[illegible]	3·91	56	10·44	208	38·80	114	21·26	23	4·29
142	189	789	19	10·0	4	2·11	[illegible]	21·69	67	35·45	47	24·96	11	[illegible]
120	2,549	923	273	10·7	92	3·60	334	13·1	1,114	43·70	693	27·10	[illegible]	1·68
99	588	1,423	122	20·7	[illegible]	10·37	92	15·64	212	36·00	95	[illegible]	6	1·02
	3,862		528		178		523		1,601		949		83	
				13·67		4·51		13·54		41·46		[illegible]		[illegible]

SUMMARY.—ELECTRIC LIGHTING COMPANIES IN LONDON.

Name of company.	Capital (nominal) £	Number of years in existence.	Stations.	Total indicated horse-power engines.	Number of lamps equivalent to 32-watt lamps now connected.	System.	Length of cond't pipe or single run of main.	Lamps per mile.	Meters. Number.	Meters. Type.	Districts.
London Electric Supply Corporation, Limited.	1,250000	5	Deptford converting stations.	4,500	38,000	Alternate-current transformers (Ferranti).			136 174 14	Ferranti-Mercury. Ferranti-Wright. Frager.	Parishes of St. James, St. George, Chelsea, Rotherhithe, Bermondsey, Clerkenwell, St. Mary, Newington, Lambeth (part of), St. Martin (part of), St. Margaret and St. John, Westminster. Greenwich district, St.
Metropolitan Electric Supply Company, Limited.	500,000	2½	Whitehall. Sardinia-street. Rathbone-place. Manchester-sq're.	600 3,000 1,200 2,000	44,598	Direct current and batteries. Alt'rn'te c'rr'nt trans (Westinghouse). Do. (Parker).	30 miles.	1,486	26 378	Aron. Westinghouse.	
House-to-House Electric Supply Company, Limited	350,000	2	West Brompton.	600	12,898	Transf'rm'rs (Lowrie-Hall).	8½ miles.	1,517	71 168	Lowrie-Hall Westinghouse.	
Westminster Electric Supply Company, Limited.	214,765	2	Millbank-street. Dacre-street.* Eccleston-place.† Davies-street.†		7,540	Direct current and batteries. " " " " " "			93	Aron.	
Kensington and Knightsbridge Electric Supply Company, Limited	300,000	4	Kensington-court. Chapel-place.	1,560 and Howell batteries.	24,850	Direct current and batteries (Crompton).	10½ miles.	2,366	200 90 34	Aron. Hookham. Aubert.	
Chelsea Electric Supply Company.	108,000	6	Draycott-place & three distributing stations.	Batteries E.P.S.	19,500	Direct current and batteries (King).§					
Notting Hill Electric Supply Company.	100,000	1	High-street.‡								Parish of St. Mary Abbott, Kensington (portion of).
St. James and Pall-mall Electric Supply Company.	100,000	2½	Duke-street.	1,960	23,174	Direct current.	4½ miles.	5,452	190	Aron.	Parish of St. James.
St. Pancras Vestry.			Stanhope-street.†			Direct current.					Parish of St. Pancras.
The Electricity Supply Corporation, Limited (formerly Messrs. Gatti).			Strand.	600	8,500	Direct current.				Frager.	Parish of St. Martin's-in-the-Fields.
				Total	179,060	Lamps equivalent to 8 c.p. each.		Total...	1,573		

* Temporary station. † Now in progress. ‡ Nearly complete, and another station not yet commenced. § As published in the *Engineer*, Oct. 24, 1890.

mostly used, that a really efficient 100-volt 8-c.p. lamp is much needed; the present lamps of this kind have such a short life that customers, contractors, and electric supply companies would all hail its advent as a boon.

We must also remember that the future progress of electric lighting depends in no small measure on the lampmakers, and as the manufacture of the incandescent lamp will soon be open to all (owing to the expiration of the present patents) the absolute necessity of a standardising laboratory must compel its adoption where not only instruments but lamps can be tested, so that people may know when they ask for an 8-c.p. 100-volt lamp, with or without a guaranteed life of say 10,000 hours at an efficiency of 3½ watts per candle, that they get what they have asked for.

That this question of lamp efficiency is of importance to customers and supply companies alike few will doubt, and the following table will probably explain itself:

Watts per candle.	Candles per 1,000 watts.	Lamps per 1,000 watts.			
		8 c.p.	16 c.p.	20 c.p.	32 c.p.
2·00	500·0	62·5	31·2	25·0	15·6
2·25	444·5	55·5	27·7	22·2	13·9
2·50	400·0	50·0	25·0	20·0	12·5
2·75	363·6	45·4	22·7	18·2	11·4
3·00	333·3	41·7	20·8	16·7	10·4
3·25	307·6	38·4	19·2	15·4	9·6
3·50	285·7	35·7	17·8	14·3	8·9
3·75	266·6	33·3	16·7	13·3	8·3
4·00	250·0	31·2	15·6	12·5	7·8

We see then how an improved lamp efficiency will benefit the supply companies, by enabling them to increase their lamp connection.

The following table will appeal most strongly to all users of the incandescent lamp; but it must be assumed that an increased efficiency is not obtained at the expense of a reduced life of the lamp.

The most satisfactory feature, however, of the present Edison-Swan lamps is the uniformity of their voltage; and the scientific department of the Edison and Swan Company's works is to be congratulated on the assistance they have given to the industry, by practically enabling voltmeters to be set by photometrical tests of the lamps.

Cost per Annum per 8-c.p. Lamp at 8d. per Unit, Lamps Burning an Average of:

Per day.	½ hour per day.	1 hour per day.	2 hours per day.	3 hours per day.	4 hours per day.
Hours per annum.	182·5	365	730	1,095	1,460

Cost per annum with lamp efficiency of:

	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
2 watts per candle	0 1 11	0 3 11	0 7 10	0 11 9	0 15 8
2·25 ,, ,, ...	0 2 2	0 4 5	0 8 9	0 13 2	0 17 6
2·50 ,, ,, ...	0 2 5	0 4 10	0 9 9	0 14 7	0 19 6
2·75 ,, ,, ...	0 2 8	0 5 4	0 10 9	0 16 1	1 1 5
3·00 ,, ,, ...	0 2 11	0 5 10	0 11 8	0 17 6	1 3 4
3·25 ,, ,, ...	0 3 2	0 6 4	0 12 8	0 19 0	1 5 4
3·50 ,, ,, ...	0 3 5	0 6 10	0 13 8	1 0 5	1 7 3
3·75 ,, ,, ...	0 3 8	0 7 4	0 14 7	1 1 11	1 9 2
4·00 ,, ,, ...	0 3 11	0 7 10	0 15 8	1 3 6	1 11 4

It may be thought that an estimated use of a lamp for only about 200 or 300 hours per annum is very low, but it should be remembered that the electric light need only be used when it is required, as the ease of switching it on and off makes us forget all our past troubles in hunting for gas-taps, matches, and broken gas-globes. With ordinary care the average cost of burning an 8-c.p. lamp for ordinary domestic use need not exceed 10s. per annum.

Of course much depends on the wiring contractor, who not only has to be an accomplished art critic in designing or selecting the brackets, pendants, etc., but he has also to suggest the most advantageous positions for the lamps and switches. A switch placed near the door of every room, and not less than two lamps in any room, will probably save annoyance.

The greatest progress has been made in the wiring of houses; not only is more work done, but it is better done, and on more mechanical principles; for whereas some years ago a single main would have been run from top to bottom of a house with numerous T-joints, independent circuits will now be wired, and all brought to a neat form of distributing board.

The effect of the extra care which is now taken with this work is proved by the following table of insulation tests, taken with 100 volts at 200 houses.

Insulation Tests of Internal Wiring (taken with 100 volts—Evershed Ohmmeter).

Number of points.	—	Test megohms.
5 to 10	Average of 15 houses	4·0
10 ,, 15	,, 23 ,, ...	3·5
15 ,, 20	,, 18 ,, ...	2·8
20 ,, 25	,, 13 ,, ...	2·7
25 ,, 35	,, 33 ,, ...	1·8
35 ,, 40	,, 12 ,, ...	1·5
40 ,, 50	,, 16 ,, ...	1·2
50 ,, 60	,, 12 ,, ...	1·1
60 ,, 70	,, 9 ,, ...	1·0
70 ,, 120	,, 14 ,, ...	·4
120 ,, 220	,, 9 ,, ...	·25

I hoped to have been able to place before you some record of the improvement in the health of London owing to the progress of electric lighting, but so much has already been said and published about it that further facts appear needless. It is simply melancholy to see so many of our churches and halls not only burning their gas jets for lighting, but also for "warming" the building. If culpable negligence amounts to manslaughter, the people responsible for this atrocity ought to receive their deserts.

Having now placed before you some account of the progress of electric lighting in London, I must ask you to compare our metropolis with other cities, and leave you to judge whether we are so very far behind them as some would have us believe. Is it not more probable that other countries will be glad to avail themselves of the experience which London must gain in the working of so many distinct systems?

PHYSICAL SOCIETY.—Nov. 28, 1890.

Prof. W. E. Ayrton, F.R.S., President, in the chair.

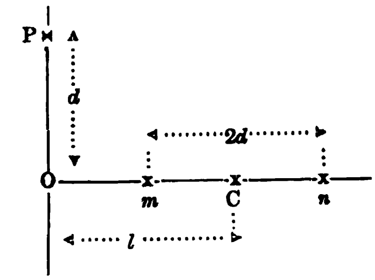
The following communications were made:

"**Additional Notes on Secondary Batteries,**" by **Dr. J. H. Gladstone, F.R.S.**, and **Mr. W. Hibbert, F.I.C.** After referring to the debatable points as to what compounds are formed and decomposed in the working of such batteries, the authors give the results of their examination of the red substance formed by the action of dilute sulphuric acid on minium, and which Dr. Frankland believes to be a compound having the formula $Pb_3S_2O_{10}$. The ultimate analysis showed 72 per cent. of lead. A portion of the substance was treated with a 3 per cent. solution of ammonium acetate to dissolve out any normal sulphate that might be present; this left a residue much darker in colour than the original substance, and containing 82 per cent. of lead. PbO_2 contains 86·6 per cent. of lead. The colourless solution yielded a ratio of Pb to SO_4, varying from 2·0 to 2·15; pure Pb SO_4 requires a ratio of 2·16, and Dr. Frankland's compound 3·23. From these results the authors conclude that the portion dissolved was not a basic sulphate, and that the evidence tells against the original substance being a chemical compound. The authors have also continued their comparative experiments on the action of spongy lead on dilute sulphuric acid, either pure or containing a small quantity of sulphate of soda. After the experiments had gone on for five months the residues were analysed; that from the pure acid showed 82 per cent. of lead sulphate and 18 per cent. of metallic lead, whilst that mixed with sodium sulphate gave 89 per cent. of lead sulphate and 11 per cent. of lead. They therefore conclude that although the action of acid on lead is initially diminished by the presence of sodium sulphate, the final result is rather the other way. **Mr. G. H. Robertson**, who had used ammonium acetate to analyse plugs from storage cells, said he had arrived at results much the same as those stated by the authors. **Mr. Swinburne** said Dr. Frankland was absent, but without agreeing with him he would suggest that Dr. Frankland might say that ammonium acetate decomposed the subsalt, $Pb_3S_2O_{10}$, and then dissolved the sulphate, $PbSO_4$. The question might be attacked by acting on equal quantities of the substance and the mixture, PbO_2, 2 $PbSO_4$, in a calorimeter with ammonium acetate, to see if the same heat is produced. This would show whether the substance is a mixture or a compound. **Dr. S. P. Thompson** was glad that the authors allowed a possibility of basic sulphate being formed, for it was well known that an almost irreducible sulphate resulted from leaving a cell nearly discharged. This, he thought, would point to a possible formation of a basic sulphate from PbO and $PbSO_4$. **Mr. Swinburne** did not see where the PbO came from, except in newly-pasted negatives, and he knew of no evidence of an intermediate stage of oxide on the plates. They appear to change directly to sulphate. **Dr. Thompson** said that a rapid discharge was known to produce basic salts. **Mr. Swinburne** thought this was due to deficiency of acid near the plates. Peroxide, he said, could not be formed on the negative, without the acid was heterogeneous and gave rise to local currents. **Mr. W. Hibbert**, referring to Mr. Swinburne's statement, said he had put one plate of spongy lead into strong acid and another into weak, and from this arrangement obtained a fairly large current. As regards the basic sulphate spoken of by Dr. Thompson, he did not think there was much probability of its being formed. Time, he said, had an

important influence on a partially discharged cell, and he would not expect to easily reduce the $PbSO_4$ formed by the long-continued action of lead on sulphuric acid. The **President** enquired whether Mr. Hibbert's argument would apply to a fully-charged cell? **Mr. Hibbert,** in reply, said that in this case the time required to produce sufficient sulphate to be irreducible would be very much larger, for in a partially discharged cell much sulphate was already formed. **Dr. Gladstone** said he had anticipated that Dr. Frankland would raise the objection referred to by Mr. Swinburne. As far as he was aware, there was no direct evidence either way, but he thought the suggested decomposition was improbable. If he acted on a mixture of PbO_2 and $PbSO_4$, he would expect to get the results actually obtained. Mixtures, however, were difficult to deal with, and the results not conclusive, for the physical condition of the mixture was not the same as that of the actual products. Referring to Dr. Thompson's remarks, he understood that it was the basic sulphate which he (Dr. Thompson) considered irreducible. Dr. Frankland, however, believed this sulphate more easily reduced than $PbSO_4$. The **President** remarked that he thought Dr. Frankland had two reasons for his belief in the existence of the basic sulphates. One of these was the difficulty in reducing normal sulphate, whilst the other was based on the rapid fall of E.M.F. at a certain part of the discharge. It was at this point that Dr. Frankland thought the new sulphate formed, and to meet this argument it was necessary to find some other explanation of the rapid fall. In this connection he (the President) enquired whether there was sufficient peroxide formed on the negative plate to account for the drop. On this point **Dr. Gladstone** could not speak decisively.

"**An Illustration of Ewing's Theory of Magnetism,**" by **Prof. S. P. Thompson, D.Sc.** A number of small "charm" compasses were placed together on a glass plate of an ordinary vertical attachment to a lantern. A large magnet at a distance served to neutralise the earth's field, and a coil enabled a magnetising force to be applied in the plane of the needles. By this apparatus all the various phenomena exhibited by Ewing's model were beautifully shown on a screen. In the course of his experiments Dr. Thompson had found that when small magnets placed at moderate distances apart were used it was much more necessary to neutralise the earth's field, in order that they might set themselves according to their mutual attractions, than when larger magnets were employed. A weak field directed the small openly spaced magnets, whereas with larger ones their mutual actions were much more powerful. This fact may, he thought, throw some light on the molecular groupings in magnetite (loadstone). This substance exists in two forms, one crystalline and the other of a heterogeneous structure. The former variety exhibits no magnetic retentiveness, whilst the latter is decidedly magnetic. As far as he was aware, no sufficient explanation had been given of the non-retentiveness of the crystalline variety. A difference in the molecular distances or grouping might account for the peculiarity. **Mr. Boys** said it was rather curious that Prof. Rücker had just devised a somewhat similar illustration of Ewing's theory, and he exhibited it at the meeting. It consists of little magnets made of long U-shaped pieces of watch spring, pivoted by glass caps on needle points; the needle points are fixed in little discs of lead stuck on a sheet of glass, which forms the base of a glass box. An open helix surrounding the box serves to apply magnetic force. **Mr. Swinburne** called attention to two theoretical points. First, as regards susceptibility (which he regarded as a mere ratio and not a property), he said that if particles of iron at a high temperature rotate, as has been supposed, the susceptibility should be negative, and Prof. Ewing had some reason to think that this was the case. The next point concerned the loss of energy when an armature rotates in a strong magnetic field; this, he said, was known to be considerable, whereas if Ewing's theory is correct, he would expect little or no loss, for all the little magnets would always put themselves in the direction of the field, and would never pass through positions of unstable equilibrium. The **President** said he had discussed the question of negative susceptibility some years ago with Dr. Lodge with reference to the drop in the characteristics of dynamos, but he was not aware that any direct evidence had been obtained. **Prof. Perry** thought negative susceptibility might be possible in strong fields, but not in weak ones. **Mr. Swinburne,** on the contrary, considered its existence would be more marked in weak fields. **Mr. H. Tomlinson** said he had tried experimentally whether the susceptibility of nickel, when heated above its critical temperature, was negative, but he had not been able to detect it, although his apparatus was very sensitive.

"**The Solution of a Geometrical Problem in Magnetism,**" by **Thomas H. Blakesley, M.A.** The problem referred to was the following: Given the two poles of a magnet and a straight line intersecting at right angles, its axis produced, to determine at what point this line is parallel to the field. The question is of scientific interest because if the point be found experimentally, the distance between the virtual poles of the magnet can be determined, whilst it is important practically from its bearing on the deviation of ships' compasses in certain cases. The instances in which it would apply are pointed out in the paper. Assuming the points m and n (see figure) to be the positions of the virtual poles, and P the required point, it is shown that $\frac{m}{(d^2+m^2)^{\frac{3}{2}}} = \frac{n}{(d^2+n^2)^{\frac{3}{2}}}$ where O $m = n$, O $n = n$ and O P $= d$. From this the expression $\left(\frac{d^2}{2mn}\right)^3 - \frac{3}{4}\frac{d^2}{2mn} - \frac{1}{4}\frac{m^2+n^2}{2mn} = 0$ is deduced. Now in hyperbolic trigonometry we have a formula $\cosh^3\theta - \frac{3}{4}\cosh\theta - \frac{1}{4}\cosh 3\theta = 0$, hence making $\frac{m^2+n^2}{2mn} = \cosh 3\theta$, we have also $\frac{d^2}{2mn} = \cosh\theta$. The value of θ can be then found by aid of the tables of hyperbolic sines and cosines compiled by the author, and published recently by the society. The distance, d, can thus be determined in terms



of m and n. A method of finding the point experimentally is then described, and the distance between the poles ($2d$) shown to be given by the expression $\frac{d}{l} = \tanh\frac{3\theta}{2}$, where $\frac{l}{d} = \sqrt{\frac{\cosh 3\theta + 1}{4\cosh\theta}}$, l being the distance, O C. The latter function can be deduced from the tables already referred to. Experiment shows that the distance between the virtual poles soon approaches the length of the magnet, as d increases. The strength of the field at P is given by the expression $\frac{4M}{d^3}\frac{\cosh^2\theta}{4\cosh^2\theta - 1}$, where M is the moment of the magnet. This can be simplified by arranging d and l so that $\cosh^2\theta = \frac{5}{4}$, and then becomes $\frac{5}{8}\frac{M}{d^3}$. Under these conditions $\frac{l}{d} =$ ·85065, and, therefore, the angle O C P = 40deg. 23′ 10″.

DOVER.

Report of Mr. I. A. Timmis on the lighting of Dover by electricity:

To the Town Clerk.—Dear Sir,—I beg to say I have carefully considered the conditions which exist and have to be dealt with in any scheme for lighting the town of Dover by electricity.

You have advised me that in the first instance it is contemplated to light only the portion coloured dark pink on the map in your offices; but this in no way interferes with economy or efficiency of the system which I beg to recommend hereinafter. The town of Dover whether taken in part (part coloured dark red on plan) or as a whole (within the municipal boundary) does not cover a large area, and the uniformity of the distributed light requirements is a most marked feature.

Then the varied character of the uses that light is required for, and especially the large amount used during part of the night.

All these are noticeable features, and may be summed up thus: 1. Limited and compact area. 2. Large demand within that area. 3. Uniformity of load at the same hours of each day in the same season. 4. Large quantity required during greater part of the night.

These conditions make it, I venture to advise, imperative to adopt a low-tension direct-current system, with the mains laid on the three-wire system. By this means much economy is effected.

If very long distances have to be reached, and large amounts of electricity sent over the mains, clearly it is a question of high pressure and small mains, or low tension and large and costly mains, and it is generally conceded that theoretically the former plan is the most economical, provided, of course, that the alternative is disallowed of putting down more than one charging station on account of the extra dead expenses incurred in minding and working and keeping in repair more than one mechanical plant.

I am of opinion, however, that this last objection is not a practical one, and I am convinced that the great improvement in the evaporating power of moderate sized boilers, the wonderful efficiency of high-speed engines since 1888, and the automatic arrangements for stoking and working, have done away with the great expense of management, which till recently was a serious matter.

I consider that it is beyond all doubt that the loss of electricity in a high-tension system through imperfect contacts and transformers is immense, and one which, as time goes on, must increase.

I have ventured to make these few remarks on high tension distribution, because there is a large amount of capital and energy embarked in it, but my own conviction from experience and observation is that the low-tension systems are far more efficient—they ensure better and more regular light, and are far safer.

The three-wire system is most easy to fit, and saves a very heavy percentage in the cost of the mains in the low-tension systems. As I have pointed out before, there is really no excuse for even considering a high-tension system for your town.

One charging and generating plant will be ample in dealing with the smaller area proposed, and also afterwards for the greater portion within the municipal boundary, and it should be placed where the mains could radiate through the various parts of the district in about equal lengths.

The engines should be compound, high-pressure, direct-acting, served with steam from locomotive boilers, and driving shunt-

wound dynamos. The arrangements for lagging feed-water heaters and steam-pipes being very carefully looked after.

The mains should be carried in troughs underground and well-insulated, and the lamps used in ordinary buildings exclusively incandescent of 16 c.p., and of course in places 8 c.p. (two in series); incandescent lamps of 200 c.p., and using about six amperes and the same voltage – viz., 100 should be used in open spaces and in the streets, and the present gas lamps with suitable reflectors can be used, but I am of opinion that special lamp-posts or house brackets should be put up. I am much opposed to streets being lighted with arc lights, and I do not see that there are any arc lights need be used even in the harbour.

The number of lamp-posts in the streets, as compared with the present, can be considerably lessened, and the light should be higher than the lanterns of the present posts.

I may remark here that in recommending the low-tension three-wire system with incandescent lights, I not only do so on the score of giving the maximum of light, but also the minimum of trouble and expense in maintenance.

I have dealt so far with lighting the district, its public buildings, its streets, and open spaces and houses by means of incandescent lamps of about 100 volts, and such candle-power as will be advisable (but principally 16 c.p. and 200 c.p.).

The electric current being generated by and supplied direct into the mains from shunt-wound dynamos, driven direct by high-speed engines using high-pressure steam from locomotive boilers. And as the demand rises and falls the current would be regulated by a regular attendant. This arrangement works admirably in practice. But there must come a time in the 24 hours when the consumption will fall below one-sixth, or say 16 per cent. of the maximum demand, and I am convinced that when this occurs it will be advisable to supply this small, and in all human probability variable and uncertain, demand from a battery of accumulators. This battery will be charged by the main generating plant. In addition to its great usefulness in supplying the small amount of lighting above-named it would act as a regulator during the main lighting.

As regards the amount of plant requisite I can only give my calculations for the guidance of your honourable Council, and they are as follows:

The district marked dark red upon the map contains in all, I calculate, 10 miles of main and small streets, and by judiciously placing the lamps one-half the present number would be required, and I venture to think 20 to the mile, or 200 in all, would be sufficient.

I assume, after careful comparison, that some 18,000 to 20,000 would suffice for the district; and I should arrange for building to hold that amount of generating plant, and land for double that plant should be arranged for. I do not consider that more than 100ft. square is absolutely necessary for the plant at first, but it is more economical to have fitting shops and offices on the same floor, instead of overhead, if land can be had cheaply.

The supply of the electric current should be by contract at per lamp or space lighted in streets and open places, but by quantity consumed in buildings. The meters now in use are perfectly reliable. The price charged in similar installations is 7d. per Board of Trade unit, which in London secures customers. I can show you one installation which has in 15 months supplied 5,285 lamps.

The cost of a plant to light the streets and districts above named, and give, say, 2,000 e.h.p., or 200 amperes, would roughly be as follows: Engines and boilers, £15,000. Dynamos and batteries, £15,000, or 30s. per lamp.

The cost of buildings may be anything from £1,000 to £5,000 or even more, according to the ground and their distribution. The cost of supply to a house or building for a customer of wires, etc., may be for 10 lights £12, but for 100 lights £100, exclusive of electroliers. The cost of laying street mains and lamps with their posts is more than the cost of gas pipes and gas lamps on account of the mains, which at first are somewhat an unknown quality, but would only grow with the demand.

The following figures will give a far better idea than any cost estimate, which can be given accurately when the amount is decided on to be put down.

The amount charged in similarly lighted districts—*i.e.*, with this system—is 7d. per unit as stated above, but in other places this varies as high as 1s. A unit being 1,000 watt-hours, and at 1s. is equal to about 6s. per 1,000ft. of gas, so that at 7d. it compares favourably with low-priced gas. Now the cost of production from experience by this system at 3d. per unit sold and supplied and the profits are obvious.

I beg especially to point out that the question of efficient reflectors must be kept carefully in mind, and I am convinced that the whole question of electric supply, not only in England, on the Continent, and in the United States, is so thoroughly understood, and working with such commercial success, that your honourable Corporation will act wisely in keeping that supply in their own hands, and also keeping the supply of the necessary fittings, wirings, and instruments in their own hands, or at least under their own control.

I do not of course include accessories—*i.e.*, electroliers—which may be plain or ornamental, according to the taste and the fancy of the purchaser.

There is great economy, not only to the user but more especially to the supplier, in having the wiring and contact switches done by a regular and responsible staff. Too much importance cannot be attached to this.

I shall hope to be in Dover next Tuesday, to attend the meeting of your honourable Council, and will get out before then some comparative figures, showing what the relative proportion of cost of plant, etc., is if one half of the plant is put down (*i.e.*, 1,000 e.h.p.), or one quarter, or the whole.

I trust this information and particulars will enable your honourable Council to decide in favour of the scheme I strongly advise.

COMPANIES' MEETINGS.

WESTERN COUNTIES TELEPHONE COMPANY.

An extraordinary general meeting of the Western Counties and South Wales Telephone Company, Limited, was held on Friday, at the Grand Hotel, Broad-street, Bristol, Mr. Charles Nash presiding. The Secretary (Mr. Henry F. Lewis) having read the notice convening the meeting,

The **Chairman** moved the adoption of the following: "That the Directors be, and they are hereby, authorised by this general meeting to borrow any further sum or sums of money on such security (but not so as to prejudice existing debentures) and terms as to interest or otherwise as they may deem fit, and to secure the same by debentures upon the whole or any part of the property, funds, assets, or effects of the Company, and so that any sum not exceeding £80,000, including the £50,000 previously authorised and issued, may be owing at one time, but so that the money to be borrowed under the authority of this resolution or consent shall not bear a higher rate than 6 per cent. per annum, nor (without the consent of the National Telephone Company, Limited) a higher rate than 5 per cent. per annum.

He would say a very few words upon the progress of the Company's business during the present year. The number of subscribers to the exchange and to the trunk lines in 1885 was 779, in 1887 it had increased to 2,034, and in November, 1890, it had increased to 3,540. As to receipts, after the payment of royalties, they had increased from £8,064 in 1886 to £21,286 in 1889, and judging from the progress made during the present year he had no doubt that the amount for 1890 would exceed £26,000. It was also satisfactory to find that the increase was going on at a more rapid ratio than it was last year. In 1889 the increase in the business was at the rate of £325 per month; during the present year the increase had been at the rate of £411 per month—so that the increase on that of last year had been at the rate of about £1,000 per annum. All that had required capital to be expended, and that was the reason of the proposal now to issue £30,000 on 5 per cent. debentures. He need not say much about that. They believed the security was an excellent one. The surplus remaining last year, after paying interest on existing debentures, was £6,848. The surplus this year would certainly be very much larger, and the interest upon the debentures now proposed to be issued would be only £1,500, so that it appeared to the Directors that the security offered was a very excellent one.

Mr. Read seconded the motion. He remarked that the progress of the Company's business was satisfactory to the shareholders in every sense.

In reply to a question as to the expiration of patent rights at a future period, it was stated that the Company were covering their district so well that there would be little or no room for any competing company.

The motion was unanimously adopted.

NEW COMPANIES REGISTERED.

J. Tylor and Sons, Limited.—Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £100,000 in £10 shares. Object: to carry on business as mechanical and consulting engineers, sanitary engineers and contractors, etc., manufacturers of electrical plant and apparatus. The first subscribers are:

	Shares.
W. H. Tylor, 2, Newgate-street, E.C.	1
J. J. Tylor, 2, Newgate-street, E.C.	1
W. B. H. Drayson, 2, Newgate-street, E.C.	1
P. Bright, 2, Newgate-street, E.C.	1
J. S. Maples, 2, Newgate-street, E.C.	1
W. S. Salter, 2, Newgate-street, E.C.	1
T. Allsop, 2, Newgate-street, E.C.	1

There shall not be less than three nor more than five Directors; the first are the first four signatories. Qualification: Chairman, 300 shares; the other Directors, 100 shares. W. B. H. Drayson and P. Bright are appointed managing directors on terms to be agreed. Remuneration of other Directors, £60 each.

Foreign Electric Date and Time Stamp Company, Limited. Registered by F. Fearon, 25, Parliament-street, S.W., with a capital of £100,000 in £1 shares. Object: to acquire an invention of an electro-mechanical date and time stamp, for which patents have been obtained under the patent laws of France and Italy, numbered respectively 188,735 and 26,377. The first subscribers are:

	Shares.
E. Berlin, 17, All Saints'-road, W.	1
J. R. Akerman, 139, Minories	1
J. P. Nurse, 16, Barforth-road, Nunhead	1
G. J. Pocock, 4, Oswyth-road, Camberwell	1
J. S. Stevens, 90 and 91, Queen-street, E.C.	1
P. J. Dysart, 4, Southwark-bridge-road	1
E. G. Taylor, 46, Brighton-road, London	1

There shall not be less than three nor more than seven Directors; the first to be appointed by the subscribers to the memorandum of association. Qualification, £100. Remuneration, £600, divisible.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The traffic receipts for the past week amounted to £5,282.

Great Northern Telegraph Company.—A half-yearly interim dividend at the rate of 5 per cent. per annum is announced by the Board, payable on the 1st prox.

Crompton and Company.—The Directors have declared an interim dividend upon the preference shares, for the half-year ending September 1st last, at the rate of 7 per cent. per annum.

Western and Brazilian Telegraph Company.—The traffic receipts of this Company for the past week after deducting the fifth payable to the London Platino-Brazilian Company, amounted to £4,154.

West Coast of America Telegraph Company.—The coupons due December 31st on the debentures of this Company will be paid by Messrs. Barclay and Co., Lombard-street. Coupons should be left three clear days for examination.

United River Plate Telephone Company.—It is notified that the transfer books of the 5 per cent. debenture stock of the Company will be closed to 31st inst. (inclusive), for the purpose of preparing the half-yearly interest warrants.

Eastern and South African Telegraph Company.—Notice is given by the Company that the coupons due January 1st next on their 5 per cent. mortgage debentures will be paid on and after that date by Messrs. Barclay, Bevan, and Co., Lombard-street, E.C.

Eastern Extension Telegraph Company.—The Directors have declared an interim dividend for the quarter ended September 30th of 2s. 6d. per share, tax free, payable on January 15th. The coupon on the Company's 5 per cent. Australian Government Subsidy debentures due on the 1st of January will be paid by Messrs. Barclay, Bevan, and Co., 54, Lombard-street, E.C. Coupons must be left three clear days for examination.

PROVISIONAL PATENTS, 1890.

December 8.

20006. **Protective and insulating boxes for subterraneous telegraph conduits.** Charles Huelser, Temple-chambers, London. (Hermann Paradies, Germany.)

December 9.

20019. **Improvements in circuits for electric railways.** Frank Weidener Sabold, 52, Chancery-lane, London. (Complete specification.)

20043. **A combination of telephones and mechanical signals.** George Lee Anders and Charles Herbert Elliot, 10, Bush-lane, Cannon-street, London.

20053. **Improvements in and relating to electric signals for engines.** Peter Jensen, 77, Chancery-lane, London. (Harold Green Underwood, United States.)

20062. **An improved perforator for automatic telegraphy.** Samuel Dickinson Williams, Moorlinch House, Clytha Park, Newport, Mon.

20063. **Improved apparatus connected with column printing, telegraphically and otherwise.** Samuel Dickinson Williams, Moorlinch House, Clytha Park, Newport, Mon.

20088. **Improvements in the method of driving certain types of percussive rock drills and other tools by electric power.** Llewelyn Birchall Atkinson, 1, Queen Victoria-street, London.

20094. **Improvements in electric traction increasing system for railways.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

20099. **Improvements in telephone exchange apparatus.** John Edward Kingsbury, 24, Southampton-buildings, London. (The Western Electric Company, United States.) (Complete specification.)

20100. **Improved means for controlling the supply of electric current to electric mains from a dynamo or dynamos.** Peter William Willans, 24, Southampton-buildings, London.

20102. **An improvement in dynamo-electric and electro-dynamic machines.** Arthur Salisbury Baxendale, 28, Southampton-buildings, London.

20111. **Improvements in apparatus for use in the electrolytic decomposition of metallic salts.** Henry Harris Lake, 45, Southampton-buildings, London. (Isaiah Lewis Roberts and Thomas Henry McGraw, United States. (Complete specification.)

20115. **Improvements in what are known as automatic or coin-freed dynamometers.** Charles Arthur Barrett and Alfred Barrett, 4, South-street, Finsbury, London.

20121. **Improvements in thermometric and fire alarms.** J. B. Charles Dion, 53, Chancery-lane, London.

December 10.

20134. **Improvements in suspenders for suspending electric light and other cables from a carrying wire.** William Paul James Fawcus and Edward Woodrowe Cowan, Cathedral-chambers, Chester. (Complete specification.)

20126. **Improvements in galvanic batteries.** Clarence Edward Dutton, jun., 2,024, R St., Washington, United States. (Complete specification.)

20146. **An improved electric lamp.** Gilbert Scott Ram, 32, Oakley-square, London.

20169. **An improved mode of effecting electrical distribution.** Albert Harris Howard, 6, Bream's-buildings, London.

20175. **Improvements in electric meters.** Alphonse Frager, 28, Southampton-buildings, London.

20193. **Improvements in or relating to the electro-chemical extraction of gold, silver, and other precious metals from their ores.** The Electrical Inventions Company, Limited, and Emil Andreoli, 323, High Holborn, London. (Complete specification.)

December 12.

20289. **Improvements in and relating to the manufacture of insulating compositions for electrical uses.** Turner D. Bottome, Hoosick, New York, United States. (Complete specification.)

29294. **Improvements in junctions for electric conductors.** Malcolm Sutherland and Andrew Jackson McGeoch, Temple-chambers, London.

20307. **Improvements in electrical switches.** Carl Georg Dahlgren and John Hugo Svensson, 18, Buckingham-street, Strand, London. (Complete specification.)

20321. **Improvements in the lighting of tables and the like by electricity.** O. H. Stovell, 55, Chancery-lane, London.

20329. **Improvements in and relating to transformers for electric currents.** Arnold Beaumont Woakes, 70, Chancery-lane, London.

20332. **A combined arrangement of switches and gearing for controlling any number of dynamos and engines from one or more fixed positions.** Sidney Hargreaves and Reuben James Bott, 38, New Bridge-street, London.

December 13.

20360. **Improvements in electric meters.** Samuel Leith Tomkins, of the Electric Meter Company, Limited, 25, College-hill, London.

20372. **Improvements in electrical switches.** Charles Henry Cathcart, 57B, Hatton-garden, London.

20379. **Improved underground electric conduit.** John Pitt Bayly, 18, Fulham-place, Paddington, London. (Charles Edward Loth, United States.)

20401. **Improvements in the electrolysis of chloride and other solutions.** Emil Andreoli, 323, High Holborn, London. (Complete specification.)

SPECIFICATIONS PUBLISHED.

1880.

315. **Generating, etc., electricity.** Lake (Houston and Thomson). (Second edition.) 1s. 5d.

1889.

19079. **Electrical cut-outs.** Bryan. 6d.

19813. **Heating, etc., metals by the application of electric currents.** Werndley and Foster. 11d.

20082. **Signalling numerals, etc., by electric light.** Turnbull. 4d.

20582. **Electric meters, etc.** Einstein and Kornprobst. 8d.

20646. **Printing telegraphic apparatus.** Cassagnes. 1s. 1d.

20198. **Dynamo-electric machines.** Thompson (Stanley). 8d.

1890.

42. **Electric cables.** Smith. 6d.

615. **Electric switches, etc.** Evered and Rudling. 8d.

1658. **Electricity meters.** Elieson. 8d.

3335. **Incandescent electric lamps.** Schirner. 6d.

8427. **Electric arc lighting.** Apps. 6d.

11240. **Electric arc lamps.** Johnson (Bardou). 8d.

13190. **Electromagnets, etc.** Kennedy. 8d.

13549. **Converters of alternating currents.** Kennedy. 6d.

14232. **Dynamo-electric machines.** Kennedy. 6d.

16518. **Arc electric lamps.** Gwynne. 8d.

16522. **Working metals by electricity.** Burton. 11d.

16571. **Secondary batteries.** Kennedy and Groswith. 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	20
House-to-House	5	5
Metropolitan Electric Supply	—	8
London Electric Supply	5	1¾
Swan United	3½	5
Crompton & Co., Pref.	—	5½
National Telephone	5	4½
Electric Construction	10	8

NOTES.

Royal Naval Exhibition.—The exhibition will be lighted by 1,700 incandescents and 400 arcs.

Durham Cathedral.—It is stated that the Dean and Chapter are thinking of lighting the cathedral electrically, obtaining their motive power from the river.

Electric Chimes.—Dr. Alva Owens, of Chicago, has recently constructed a set of bells or chimes, to be played electrically by means of a keyboard, for advertising purposes.

Mill Lighting.—Messrs. Ernest Scott and Co., Newcastle-on-Tyne, are lighting the Dunston Flour Mills, which are of enormous size, and have been built by the Co-operative Wholesale Society.

Telegraph Congress.—The International Postal and Telegraphic Congress will meet at Vienna on May 20, 1891, under the presidency of the Marquis Bacquehem, the Austrian Minister of Commerce.

Paris Telephone.—The central office of the Paris and London telephone service will be at the General Post Office, with branch wires to different parts. The Stock Exchange will have a special branch.

New Steamers for Bremen.—The Neptune Steam Navigation Company of Bremen will establish a new line of steamers next spring between Stettin and Cologne, and three new steamers are being built. These will be lighted electrically.

Pforzheim.—The town of Pforzheim in Baden, which has its own gas works, is in negotiation with Messrs. Schuckert and Co., of Nuremberg, for the establishment of a central installation for supply of electricity by means of steam power.

Treasure Trove.—A Rangoon paper writes: "An electric lighting apparatus has been discovered to be among the stores, etc., of the Insein workshops, and, from all accounts, to have been lying there for over eight years. The apparatus is said to be a new one, never having been once used."

Postal Telegraphs.—From a parliamentary return just issued it appears that when the Post Office took over the telegraphs in 1869 the first year's receipts amounted to £612,301. In 1879 the income had risen to £1,369,467, and in 1885 to £1,832,401, while in 1890 it amounted to £2,364,098.

The Telephone in France.—The charge for talking over the line between Fécamp and Havre, and Fécamp and Paris has been fixed as follows: Fifty centimes (5d.) for conversations between Fécamp and Havre, and 1f. 50c. (1s. 3d.) for conversations between Fécamp and Paris over the Fécamp-Havre and Havre-Paris lines.

Mining Lamp.—At the last meeting of the North of England Institute of Mining Engineers, the portable miners' lamps of the Mining and General Electric Lamp Company (FitzGerald's) were exhibited. One of these weighed about 3lb., and gave a light of one candle for upwards of 14 hours; the other weighed 4lb., and gave a light of two candles for seven hours.

Scarborough. — The Scarborough Local Authority have decided to make application to the Board of Trade for a provisional order under the Electric Lighting Acts, 1882 and 1888, to repeal the Scarborough Electric Lighting Order, 1883, and to have conferred upon them all the necessary powers to supply electricity for all public and private purposes within the borough.

Berwick-on-Tweed.— At the last meeting of the Urban Sanitary Authority, the Lighting Committee presented a report on the lighting of the town. The question was again referred to the committee with instructions to consider the advisability of lighting the town electrically. The Authority are paying 4s. 6d. per 1,000ft., less 5 per cent. discount, which they consider far too much.

More Light for Cairo.—An Egyptian paper announces that the Governor of Cairo, Osman Bey Fehmy, is preparing a scheme for the regulation of the lighting of the sidewalks of that city. He will reserve a sum of £10,000 to £15,000 for the lighting of those quarters of the town now deficient in light. This scheme will be submitted for the approbation of the Minister of the Interior. Electrical engineers would do well to see that the lighting is provided by electricity.

Fire at Telegraph Stores.—Between five and six o'clock on Friday morning a fire occurred at the Postal Telegraph Stores, Gloucester-road, Regent's Park. The origin of the outbreak is set down as "heat from gas light." The official report of the damage is as follows: "A back building of two floors, about 120ft. by 20ft., used as workshops and stores, about 30ft. by 20ft. and contents severely damaged by fire; rest of ditto and contents slightly by smoke and water."

Birmingham Central Tramways.—A correspondent writes: "With reference to a recent paragraph, referring to the accumulator cars on the above line, it is necessary to remark that a good deal of the excessive power expended on the working of this line has been found due to that portion of the tramways which was laid in wood by the Corporation of Birmingham having got out of gauge; this is now being put right, so that in future better results are expected."

British Association, Leeds Meeting.—The local finance committee have presented their balance-sheet, which shows a total expenditure of £1,577 4s. 8d., a sum considerably smaller than was anticipated. The guarantee fund amounted to over £6,000, of which half was called up. Of this called-up half, 57 per cent. will now be returned to the guarantors, so that the expenses of the meeting have amounted to only 21½ per cent. of the guarantee fund, instead of 50 per cent. as expected.

Bacup.—At the last meeting of the Council a letter was read from the Board of Trade calling attention to the provisions of section 10, sub-section 1, of the Electric Lighting Order, 1890, and requesting that the Board should be informed what system of electric supply the Corporation proposed to adopt, and stating that it was necessary to obtain the approval of the Board before the work was commenced. The town clerk said they were not in a position as yet to give the required information.

South London Railway.—The heavy snow in London during the last week has sorely tried the omnibus and tramcar horses, who were slipping about in all directions. It has been prosperous times for the South of London Electric Railway, which, starting just as the snow came on, has received much of the patronage that otherwise would have gone to the buses. The dangerous state of the roads, moreover, has induced the bus conductors to put up the prices to sixpence, and the invariable price of twopence at the electric railway turnstile is therefore a still further inducement to the public.

Crystal Palace Engineering School.—Major Marindin distributed certificates to the successful students of the Crystal Palace School of Practical Engineering on Saturday. The chief honour was awarded to Mr. W. G. Wales, who received a bronze medal for having, during his course through the school, obtained the necessary nine certificates, none of which were below third in order of merit. Only eight of these honours have been awarded in the eighteen years of the school's existence. In the electrical section C. B. Clay was first, and E. S. Eccles second.

Vienna-Budapest Electric Railway.—It is announced, says a *Times* telegram, that a company is about to be started, with a capital of 38,000,000fl., for constructing an electrical railway between Vienna and Budapest. The distance of 250 kilometres would be accomplished in two hours and a half by trains comprising only first-class carriages. The price of the return ticket is to be 9fl. 80kr., about 18s. As it now takes four hours and a half to travel between the Austrian and the Hungarian capitals in an express train, the saving of time promised by the new company is a boon that will seem to many more tantalising than attainable

Incandescents.—An American contemporary goes in for the following statistics: In each 16-c.p. lamp there are from four to eight grains of platinum, assuming an average of six grains per lamp, then an ounce will be sufficient for 80 lamps. Estimating the demand for 16-c.p. lamps for the year 1891, based upon reliable data, 10 million 16-c.p. lamps, or their equivalent, would not be in excess of the amount, which would give a demand for 125,000 ounces of platinum, which at present price (14dols. to 16dols. per ounce) would amount to about 2,000,000dols. The probable income from these lamps will not amount to more than 6,000,000dols., while the cost of one item alone is one-third the total income.

Brussels.—It appears, from a paragraph in a Brussels paper, that the long-delayed award of the concession for the electric lighting of Brussels is, after all, not to be awarded. The town will reserve to itself the right of supplying electric light. It will be remembered that the last scale of charges, which we gave in full at the time, specified very fully the conditions for a concession of 25 years, and even fixed the price at which the current was to be supplied. All that was to be given by persons tendering was the conditions under which the town might take over the concession and the installation in working order. After a fresh examination, the conditions tendered have been adjudged too onerous, and the resolution has been taken not to award the concession outside their own authority.

Electro-dynamic Action of Sun on Earth.—M. Zenger imitates this by the action of the dischargers of a Wimshurst machine on a hollow glass sphere. This sphere, the interior of which is silvered, is tapered like a lamp, and in the conical cavity thus obtained the end of a steel or iron axis is placed. This axis is fixed in a support, and the sphere is placed between the dischargers of the machine in such a way that the line joining the centres of the knobs does not pass through the centre of the sphere. When the handle is turned the sphere also begins to rotate, and, indeed, obeys the hand of the turner. The knobs should be placed at several centimetres from the surface of the sphere to avoid sparks. This experiment, says M. Zenger, confirms his views of the origin of the planetary movements.

Rouen.—The central station here supplies (according to a French contemporary), about 2,500 incandescents of 16 c.p. distributed among shops and business houses, and also in Rouen Cathedral. The station is situated in the Rue du Petit-salut. The machinery includes three 70-h.p. boilers, four Armington engines running at 300 revolutions per minute, and four Edison dynamos giving 120 volts and 300 amperes. The current is supplied by contract and the lamps are lighted and extinguished at different hours. Bare copper wire is used in the streets and the lines are run overhead. Gerard lamps are favoured. The writer does not seem to be much impressed with the installation as at present existing, but says it is in process of conversion. The electric light, however, has every chance, for Rouen gas "leaves much to be desired."

Electrical Standards Committee.—The President of the Board of Trade has appointed a committee consisting of the following gentlemen—viz.: Lord Rayleigh, F.R.S., and Sir William Thomson, F.R.S., representing the Royal Society; Prof. G. Carey Foster, F.R.S., and R. T. Glazebrook, Esq., F.R.S., representing the British Association for the Advancement of Science; Dr. J. Hopkinson, F.R.S., and Prof. W. E. Ayrton, F.R.S., representing the Institution of Electrical Engineers; E. Graves, Esq., and W. H. Preece, Esq., F.R.S., representing the General Post Office Courtenay Boyle, Esq., C.B., and Major P. Cardew, R.E., representing the Board of Trade—to consider whether any, and if so, what steps should be taken for the provision of electrical standards. The first meeting of the committee will be held at the Board of Trade, on Thursday, Jan. 15. Sir Thomas Blomefield, of the Board of Trade, will act as secretary to the committee.

Underground Telegraph Wires in Germany.—The underground telegraph network of the German Empire now reaches a length of 6,000 kilometres (say 3,700 miles). The expenditure reaches a total of 42 million marks (say four million sterling), and comprises the following lines: Berlin-Kiel, by Hamburg; Hamburg-Cuxhaven, by Harburg; Harburg-Grietsiel, by Bremen, Oldenburg, Emden (Grietsiel being the point of departure of the German-American cables); Bremen, Bremerhaven; Oldenburg, Wilhelmshafen; Berlin-Metz, by Magdoburg, Hanover, Wesel, Cologne, Coblence, Thionville, with branches to Barmen, Aix-la-Chapelle, and Frankfort-on-Main; Berlin-Metz (second line), by Halle, Cassel Frankfort, Strasburg, Sarreguemines, Halle-Leipzig; Strasburg-Baden, by Neufbrisach; Berlin-Dirchau, Müncheberg, Posen, Thom, Guandenz; Berlin-Eyldkunen, by Stettin, Colberg, Stolpe, Danzig, and Dirchau; Berlin-Breslau, and the Austro-Russian frontier, by Müncheberg and Glogau; Berlin-Dresden, by Cottbus; Stuttgart, Carlsruhe; Munich-Hof; Hof-Dresden. In all 16 lines, of which the last two are in process of construction.

Indiarubber.—At the last meeting of the Manchester Philosophical Society, Mr. Fred Lewis read a paper on "The Action of Various Compounds and Metals on India-rubber." Experiments carried out have shown that pure metallic copper has the greatest influence in destroying the elasticity of this substance; and, in the order named, platinum, aluminium, palladium, and lead have a similar influence. Zinc, tin, silver, iron, gold, nickel, and other metals have no objectionable influence. A thirtieth of a grain of copper sulphate per square foot of thin rubber will destroy it early. Silver and cobalt nitrates and other substances have a rapidly

injurious influence, while it is remarkable that such highly oxidising agents as bichromate of potash, chromic acid, and peroxide of hydrogen produce no deleterious effect. Samples of waterproofed cloth from three different manufacturers, containing a small quantity of copper salt used in the dye, which had been heated for 13 days, with two pieces containing no copper salt, were exhibited. The last-named samples, though two and five years old respectively, were perfectly sound, while the former had become hard and decomposed.

Cost of Transmitting Power.—The following comparisons of cost of transmission of power by various methods appeared in the *Revue Universelle des Mines*: 1. Comparative cost on 10 h.p. transmitted 1,093 yards: By cables, 1·77 effective h.p. per hour; by electricity, 2·21; by hydraulics, 2·90; by compressed air, 2·98. 2. Comparative cost on 50 h.p. transmitted 1,093 yards: By cables, 1·35 effective h.p. per hour; by hydraulics, 1·87; by electricity, 2·07; by compressed air, 2·29. 3. Comparative cost on 10 effective h.p. transmitted 5,465 yards: By electricity, 2·64 per effective h.p. per hour; by compressed air, 4·66; by cables, 4·69; by hydraulics, 5·29. 4. Comparative cost on 50 effective h.p. transmitted 5,465 yards: By electricity, 2·37 per effective h.p. per hour; by cables, 2·65; by compressed air, 2·99; by hydraulics, 3·02. Steam was the prime mover used in each of the above instances, and it appears that for long distances electricity takes the lead in economy over all other systems. It has also a great advantage in the facility with which the power may be subdivided, and there appears to be no doubt that in future mining work electricity will be much used for coal-cutting, tunnelling, hauling, pumping, etc., as well as for lighting.

Volta Competition.—A new departure in the way of competitions is announced by the *Journal de Physique Elementaire*, in which the idea seems to be to offer a prize for a new method or system of presentation in teaching, rather than for a paper or essay of the usual kind. The first prize (consisting of 100 francs and two-thirds of the sum of the entry fees), in view of the progress of elementary education, is to be awarded for "A First Elementary Lesson on the Electric Cell," leaving on one side detailed descriptions of the various types of batteries. A second prize is to be given of a complete set of the *Journal* and the remaining one-third of the fees. All the manuscripts are to be sent in before June 30, 1891, to M. Abel Buguet, editor, La Flèche (Sarthe) France; to be sent in sealed envelopes bearing motto or sign, of which a duplicate is to be sent in a letter giving name and address (which will not be given to anyone unless desired). Five francs must be enclosed as entry fee, the whole of which will be distributed as above. The jury will be appointed by vote of the competitors, and will be judged without knowledge of the names. The two selected essays will be printed in the *Journal de Physique Elementaire*, the names of the authors being withheld if preferred.

Electric Light in Durham.—We alluded to the starting of an installation at Messrs. Henderson's carpet factory, Durham, in our last issue. We are now able to give some further details. The firm have adopted the electric light owing to the difficulty of "passing colours" in the winter when there is so little daylight. This difficulty affected other parts of the works, and led to loss of money. Consequently, the firm have adopted the only artificial light that can help them out of their dilemma. The installation has been satisfactorily carried out by Messrs. Ernest Scott and Co., of Newcastle-on-Tyne, Mr. Mountain having the designing of the plant, etc. The current is produced by a "Tyne" dynamo, compound wound, capable of running 100 16-c.p. incandescents. Power is taken by countershafting from the engine driving the weaving-shed machinery. It was originally intended to light the dye-sheds only, but as a test incandescents have been fitted on several of the looms, and with excellent results. The dye-sheds are lighted by four "Tyne" arcs, and the result is all that could be wished. The lamps are dust and damp proof and have powerful reflectors, and brass has been used throughout in their construction.

Utilising Water Power.—A scheme is projected for utilising the water power falling from Lake Superior to Lake Huron, the former being 30ft. higher than the latter. The speed developed by the water in falling from one to the other at Saulte St. Marie being estimated by American authorities as a little over 90,000 cubic feet per second. The scheme for which a company has been organised is to utilise this waste energy by means of a sluice five miles long and 1,000ft. wide on the American side and a tail-race of similar dimensions on the Canadian side. Colonel Hope, who has been making calculations on the spot on behalf of the English capitalists, is reported to have found the actual velocity to be 122,000 cubic feet per second, yielding 236,000 h.p., and to have declared his willingness to "back the Saulte against Chicago," believing it will have a population of half a million before many years have passed. The company is to construct dry docks on both sides, to be filled and emptied by gravitation, and it is expected that paper mills, pulp mills, flour mills, and gold ore-crushing apparatus will speedily make their appearance. One result of the works will be the raising of Lake Superior's level by about 3in. Altogether, the Niagara Commission will have to take a back seat if this scheme gets from paper to practice.

Decreasing Cost of Incandescent Lamps.—Incandescent electric lamps are lessening in cost of manufacture while, at the same time, says the *Scientific American*, increasing in efficiency—that is to say, in length of life. This, too, in the face of a largely-advanced price for platinum, of which the wires connecting the outside circuit with the carbon loop within the globe are made. This metal, so important in electrical manufacture, has, indeed, almost trebled in price since the earlier lamps were fashioned, and still has an upward tendency, the supply being inadequate to the demand, and its scarcity forcing the substitution of other and less recommended metals in some departments of electrical manufacture. As to the little incandescent lamps; they must have it, its increased cost not proving so important as was feared, because of the discovery of more economical processes in the making of other parts of the lamp. Now, with improvements in exhausting apparatus, it costs but a tithe of the old figure to produce a more perfect vacuum; the sealing of the platinum wires is done by machinery and, as a result, a far more certain and long-lived lamp than that which once cost 1dol. may be had for considerably less than half of it, and even then leave a margin of profit for its manufacturer. From another source we learn that the 16-c.p. lamp is now being sold in America for 45 cents.

Croydon.—At a recent meeting of the Croydon County Council, the General Purposes Committee made a report on Mr. Preece's recommendations as to the lighting of the

borough (*vide E. E.*, Nov. 14, p. 433). We make the following extract from the committee's report: "The Council will see that under Mr. Preece's estimate the cost of underground wires throughout the borough will be about £60,500, as compared with £53,700, which would be the cost if 60 miles of the wires were laid underground and 40 miles were erected overhead. In addition to this sum it will, of course, be necessary to provide the installations. Under these circumstances the committee recommend that they be authorised to state in the application to the Board of Trade £150,000 (the amount of Mr. Preece's estimate) as the amount of capital which may be employed. This amount would enable either the Corporation or a company—if it should be decided to transfer the powers of the order to a company—to lay the whole of the mains and wires underground, in case the Council should hereafter decide that course to be desirable. In the course of the discussion which followed, Mr. Haggis said that Mr. Preece had given very slender details of the calculations upon which he based the estimate that £150,000 would be sufficient capital for the undertaking. Mr. Preece had evidently gone upon the assumption that the wires were to be partly overhead and partly underground, but the Council, he took it, had decided to have no overhead wires at all, therefore they must add an extra £7,000 or £8,000 at least. He thought, therefore, that £150,000 would not be sufficient, but if it went into the Bill they would be bound to confine themselves to that sum. The town clerk pointed out that the amount would not be mentioned in the Bill, but only in the statement supplied to the Board of Trade, as the Bill was being promoted by the Corporation and not by a private company. The report was adopted.

Vienna.—The correspondent of the *Standard*, telegraphing on Friday last, says: "For the last day or two the time-honoured Hofburg has been, after dusk, one great illumination, the windows looking over the Burgplatz and the Frazensplatz, or the inner square of the Hofburg, being a blaze of light. The explanation is that experiments have been made with the electric light, which is to be installed throughout the palace. For the present only 52 halls, reception-rooms, and apartments have received the new illuminant, but next spring it will be extended to the remaining 41 rooms, which are now occupied by the Emperor, the Empress, and the Archduchess Stéphanie, and are, therefore, not ready for the workmen. The incandescent system is the only one adopted, and the chief difficulty experienced in fixing it arose from the strict orders against any alteration of the character and outward appearance of the handsome candelabra, in embossed gold and crystal, which date from the time of the Emperor Francis I. In the great Ceremoniensaal alone there are 27 of these, with 54 lights apiece. The difficulty was surmounted by inserting small white lacquered wooden tubes, resembling candles at a distance, into the old lustres, each tube being fitted with a movable lamp. The entire installation, when completed, will consist of 5,250 incandescent lamps, equal to 30,000 wax candles, in the apartments, and nearly 1,000 lights in the entrance halls, galleries, and staircases—or some 7,000 lamps in all. This will be the largest installation in any one building in Europe. The length of the wires inside the building will be 15 English miles. The experiments made last night and to-night were completely successful, and it was interesting to notice how well the magnificent ceilings were brought out, and what an unsuspected wealth of colour was developed in the famous Flemish tapestries on the walls of the Privy Council Chamber and other apartments. A later telegram says that the palace of the Archduke Albrecht, which adjoins the Hofburg, is also to be lighted electrically. The installation will comprise 1,500 incandescents. The current will also be put to other uses, among other things it will be employed to heat curling-tongs in the ladies' dressing-rooms.

The Hagen Secondary Battery. — Secondary battery makers have two chief ends in view: firstly, to obtain the most permanent method of fixing the active material to the plates, and, secondly, to diminish the dead weight. A plate which fulfils the former requirement would last a very long time, for all the minor difficulties which previous types of secondary batteries have shown, such as buckling of plates, can be put right by mechanical means. Every loss of active material from the frame means a loss of capacity; if this loss can be made good by renewal the same capacity is obtained for some time; indeed, in special types it is said that the capacity is greater during the first period of use, yet this is attained at the cost of permanence of the frame, and therefore of the whole cell; or, on the other hand, the plates have not been fully formed, and are completely formed only at the purchaser's expense; such increased capacity is never to be regarded as a structural improvement. The second aim referred to above—namely, the lessening of dead weight in the plates—is of special importance in portable batteries, but should not be attained at the expense of the first. Dr. E. Lieg considers that the Hagen type shows considerable improvement over earlier forms of secondary batteries. The frame for holding the active material may be made of any of the alloys now used for such a purpose, and consists of two halves formed of ribs, crossing each other at right angles, thus leaving square openings. Each rib is in form a triangular prism, with the base outwards. Contrary to the usual custom, the halves are not cast solid along the inner angle of the ribs, but are some little distance apart, and merely held together at the crossing points of the ribs by short crossbars; the whole frame is cast in one piece. In this manner a light but strong frame is obtained, which is not only able to hold a larger quantity of active material, but holds the same permanently, for it is prevented from falling by the ribs of triangular section. The proportion of the weight of the frame to that of the active material is, in plates for stationary work, as 1 : 1, but for special purposes it can be reduced to the proportion 40 : 60. The plates for stationary work develop, in an eight-hour discharge, about 4·5 ampere-hours per pound weight of the filled plates, and about 18·1 ampere-hours per pound of active material. The E.M.F. of discharge is, for the first half of the discharge, constant at 1·98 to 2 volts per cell, and then falls gradually to 1·88 volts; after that it falls so quickly that the discharge should previously be stopped. A stationary battery of 160 ampere-hour capacity, and several smaller portable sets, have been in use for three years; the latter were used for lighting baggage cars without springs. In spite of the fact that the former battery was frequently uncharged for a long time, and was at times half dry, and in other cases had to supply current up to 100 amperes for soldering experiments, the plates show no change, neither loss of active material nor buckling. These results led Mr. Hagen to add to his lead-rolling-mills the manufacture of secondary batteries of this type at Kalk, near Cologne.—From *Abstracts* of foreign papers published by the Institution of Civil Engineers.

THE RICHARD REGISTERING METERS.

With the extension of central stations has come the necessity of having correct and continuous records of the output of these stations in current and in the variations of pressure, both for the guidance of the engineers themselves, and also for the satisfaction of complaining customers. The ingenious automatic registering meters of MM. Richard Frères, of Paris, have obtained a principal place among measuring instruments of this class, and as the English agency for them has just been taken by the General Electric Company, we think it will be interesting to give illustrations of the usual forms in which they are made.

Richard Registering Ampere-meter.

Richard Registering Voltmeter.

The Richard ampere-meters and voltmeters are made much in the same form as the well-known registering barometer made by the same firm, and so often seen tracing its zigzag blue line on ruled paper in scientific laboratories, or in philosophical instrument makers' windows. In the case of the electrical instruments the aneroid barometer is replaced by a coil of wire—thick for the ampere-meter and thin for the voltmeter—forming a two-pole magnet, in front of which is a double wing-shaped piece of iron, which is drawn up or down proportionately to the current passing. This bears a long aluminium pointer, which itself carries a morsel of solid aniline pencil, so tracing a varying line on the paper. The paper is wrapped in sheets, one a day, round a barrel rotated by clockwork, and the lines on the paper are carefully ruled for the hours of the day, and curved to the radius of the long pointer. The variations of the pointer are thus registered hour by hour, and the successive sheets can be laid away, or pasted or bound in a book for after reference. The price of these instruments is not excessive

and is the same for all sizes. The usual voltmeter registers from 90 to 130 volts, but these are also made up to 500 volts, while the ammeters are made in various sizes up to 600 amperes.

Many of our electric supply stations are already employing them, some using a considerable number, a pair for each dynamo. They are used in the Crompton station at Kensington, the Chelsea, the St. James, the Liverpool, and other central stations, and instruments are being put in at the South London Electric Railway. They form a handsome-looking instrument, standing on a table or bracket in full view of the engineers, and the sheets are very easy to inspect or replace.

NOTES ON THE CHEMISTRY OF SECONDARY CELLS.*

BY PROF. W. E. AYRTON, VICE-PRESIDENT; C. G. LAMB, B.SC., AND E. W. SMITH, ASSOCIATES.

DISCUSSION.—(*Concluded from page 549.*)

Mr. Hibbert, referring to the later paper, thought the authors had rather exaggerated the effect of peroxide on the negative plate in causing the volts to fall, for in his own experiments only a small quantity was formed. The simultaneous weakening of the acid round the plates would tend to give a rapid fall in the E.M.F., and the effect of both these actions must be studied if the subject is to be properly understood.

Dr. E. Frankland said he had read the papers with great interest, and considered them most important contributions on the subject. In one place the authors deplore the lack of knowledge of the chemical actions in cells, and not without reason; he, however, thought physicists were more to blame than chemists, for the physical actions could be readily determined, whereas the chemical charges present formidable difficulties. The substances used and produced were mixtures, and it was very difficult to separate and analyse them without producing decompositions. A valuable part of the communications was that relating to the quantity of PbO_2 formed and decomposed during the working of cells. On this point he thought the values put down for PbO_2 may be either the sesqui, or the threequarters oxide, and, in fact, the crux of the whole subject lay in the exact nature of the compound formed. Dr. Gladstone and himself had apparently arrived at different conclusions, but their differences might admit of explanation if care and time were taken in considering the matter. Another important point was the quantity of $S\,O_3$ absorbed during discharge—viz., 3·08 grammes per ampere hour. If this be translated into hexabasic acid, which he believed to be present, it gives 5·71 grammes. From his own experiments on a 10-plate cell he had found about 4·7 grammes of hexabasic acid absorbed per ampere hour whilst discharging at an E.M.F. averaging 19 volts, but when the cell was run down and discharged at an E.M.F. averaging 0·3 volt he found the rate about 3·3 grammes. He did not wish to put these numbers in conflict with those obtained by the authors, but he was strongly impressed with the idea that the two different quantities, 4·7 and 3·3, pointed to the existence of two distinct chemical reactions, one resulting in an E.M.F. of about 2 volts and the other of ·3 volt.

Mr. F. King said the results of the tests were very gratifying to the makers of cells. He commended the skill and ingenuity displayed in devising the automatic apparatus, for the labour involved in working a laboratory day and night without such apparatus is enormous. The inequality of current distribution over the surface of the plates was, he said, well-known, and the hanging type of cell was devised to remedy this defect. The first form of this type was abandoned, but more recently they had made another form—one of which was exhibited at the meeting. The current is led into the positives at two points on the top and leaves the negatives at the bottom. With this cell they had doubled the normal rate of discharge without diminishing the capacity, and also obtained a longer life. Moreover, the loss of capacity for high rates of discharge, due to the shrinkage of the negative paste, and which is so marked in ordinary types, had been avoided. The positive plates somewhat resemble those of the Tudor cell, having deep horizontal grooves along each side in which the active material is placed. The negatives are made according to Sellon's invention, in which a kind of double grid is used, the parts being displaced diagonally, so that each plug on one side communicates directly with four plugs on the opposite side, and through them with every other plug in that division of the plate. This construction causes any shrinkage of the paste to bind itself more firmly on the grid. As a result of tests on the new cell, it has been found that the capacity is greater after 500 or 600 discharges than at the beginning, whereas that of ordinary cells is considerably reduced by 400 discharges. The life of negative plates, he believed, was not well understood, but with reference to positives he said that those used on tramcars (9 plates 8in. by 5½in.) had a useful life of 70,000 ampere-hours. After one year's use their capacity is reduced 33 per cent. Speaking of the resistance of battery connections he pointed out the advisability of burning the lugs together, so as to give as complete a metallic circuit as possible. Respecting the parting and formation of E.P.S. plates, referred to in the second paper, he said that the particulars there given were totally wrong.

Mr. Swinburne thought there had never been any solid reason for doubting the formation of normal lead sulphate. The old ideas about reduction and oxidation, etc., had obscured the subject until Dr. Gladstone and Mr. Trite brought people to order about eight years ago. The difficulty of reducing ordinary sulphate electrically had been given as a reason why it could not be formed, but now its reduction or non-reduction was known to be a mere question of making contact with it. Seven years ago he had brought forward a theory that the sulphate is not a secondary product at all, and that the output of a cell is mainly dependent on the affinity of sulphion for lead. This, together with the other chemical actions, leaves some E.M.F. to be accounted for by Peltier effects, and these effects would show in the temperature coefficient. He was not aware whether colourmatic data had been obtained for the subsulphate which Dr. Frankland supposed to be present, but if so, then by working backwards evidence for or against their existence might be procured. The action of finely divided lead on sulphuric acid had, he said, been known for years, and this limited the best strength of acid to about one in four. As regards the equilibrium between the plates of a cell, he was inclined to attribute this either to the absence of PbO_2 from the positive, or of spongy lead from the negative, rather than to the presence of PbO_2 on both plates. He also thought the percentage of material really active was much less than that stated in the paper, for in some experiments of his own he had only found about 8 per cent. useful. Speaking of Mr. Crompton's colour observation, Mr. Swinburne said they were due to ferric acid formed by the action of PbO_2 on iron salts in the commercial acid. In his opinion the virtue of sulphate of soda had been greatly exaggerated, and he believed its action to be due to its enabling bad contact sulphate to be reached more easily.

Sir D. Salomons said he had noticed colourations in one or two of his cells, but had attributed them to impurities. The unequal action on different plugs had been to him a subject of common remark, and he had taken steps to equalise the distribution of current by burning on strips of lead, with good results. The bending of negatives could be presented by building up the sections rigidly. His experience with soda differed from that of Mr. Swinburne, for he had found caustic soda, in the proportion of 1 oz. to six gallons, very advantageous. Cells supplied with this electrolyte had been left charged for six weeks without injury, and had commenced to boil freely 10 minutes after the charging current was started. With ordinary acid two or three hours' charging would be required to produce the same results. In his opinion makers give extreme limits for the so-called normal working rate of the cells, and if these were divided by two or three, better results would be obtained, and would be cheaper in the long run. As regards efficiency he thought 70 per cent. to be a very fair average. The large amount of PbO_2 not acted on resulted from the interior of the plugs being as it were waterproofed by the sulphate outside. On this account thick plates possessed little or no advantage. Increasing the quantity of electrolyte, however, gives more capacity up to a certain point, but when the plates are put far apart the loss of volts becomes serious. Speaking of pasting positives with PbO_2, he said he had made good plates in this way by using very strong acid (nearly pure) in making the paste.

Mr. Bernard Drake, whilst adding his testimony to the value of the papers, thought he ought to mention one or two points of detail which might lead to wrong conclusions. For example, the loss of efficiency due to rest might lead clients to suppose that their cells ought to be used, even when they were away from home. This, he said, would be a great mistake, for the loss of capacity is due to the negatives, whereas the repairs were chiefly restricted to the positives, whose lives are inversely proportional to the amount of use. In a paper read before the British Association in 1886 he and Mr. Gorham had shown that the whole success of storage cells depended on whether the positives could be made to last a reasonable time, and to effect this it had been found necessary to overcharge them. The actual plates sent by Mr. Hall from the P. and O. offices had been badly sulphated some time ago, and were condemned. He, however, recommended overcharging, with the result now known. In these cells the density of acid used to be from 1,350 to 1,400, and although he did not now recommend such a high specific gravity, yet he thought the subject required more attention than it had received. As to the proportions of the plates, he said the negatives were intentionally made to give out first, so that the positives might not be run down, for a kind of protecting coating is formed on the positives by charging, and this is removed by discharging them below a certain point. If this coating is continually re-formed, the plates expand and buckle, and the plugs eventually drop out. Speaking of the cooling action during discharge, and also after charging has commenced, he did not see any explanation excepting perhaps that it might depend on the same cause as the rise of specific gravity which occurs after a charging has stopped. This he had found to be due to the heavy acid formed during charging falling to the bottom of the cell, and afterwards diffusing in o the general body of the liquid, thus affecting the hydrometer. In this connection he enquired whether the temperature was taken at the top or bottom of the cells. The rise of E.M.F. during the first part of a discharge after rest he attributed to the surface of the negatives being coated with a sulphate, which was reduced by the discharging current. In reference to the shrinkage of negatives mentioned by Mr. King, he said that in order to avoid blistered negatives, a mixture of litharge and sulphate had been used for pasting instead of litharge only. This method, although it presented blistering necessarily, left the plugs of a porous nature, and was liable to permit shrinkage.

The discussion was then adjourned.

* Paper read before the Institution of Electrical Engineers.

At the meeting on December 11, the discussion was continued.

Mr. S. Joyce, jun., said he had gained some experience with pasted cells when discharged at high rates, and therefore requiring frequent repairs. After several repeatings he found it very difficult to make the red lead paste stick in the positive plates, and then tried litharge plates similar to that used for negatives. Cells so made had proved very satisfactory.

Mr. D. G. Fitzgerald enquired by what authority, and for what reasons, the authors called the peroxidised plate the positive, and the spongy lead plate the negative? He himself had good reason for reversing the designations, and in this he was following the example of Volta and Berzelius. Speaking of the chemical constitution of the negative (peroxide) plate, he said it was generally believed that PbO_2 enters largely into its composition; there is, however, reason to doubt whether any of this compound is present, for the behaviour of the active substance on the plates is quite different from that of the pure peroxide of commerce. If a plate be made up of 80 per cent. of pure peroxide, and 20 per cent. of the so-called peroxide produced by electrolysis, the E.M.F. falls when the electrolytic product is spent, and the subsequent action of the cell is unsatisfactory. In his analyses of the electrolytic peroxide he had always found some percentage of moisture present, even after it had been dried at a temperature above 212deg. F. He believes the chemical changes produced by electrolysis is represented by the equation $(PbO_2)_{10}, (H_2O)_5, PbSO_4 = (H_2Pb_2O_5)_5, PbSO_4$, and that electrolytic peroxide is $H_2Pb_2O_5$. As regards the last kind of support or grid for the spongy lead, he said it was a mistake to use lead, for copper is in many cases much better. If the copper be left exposed local action takes place, but this is retarded by the addition of any alkaline sulphates. The beneficial effect of soda in secondary cells he attributed to the formation of a double salt which is easily reduced. Sulphate of magnesium has an extraordinary influence on lead plates, and by using a solution of it as electrolyte he had got discharges 30 or 40 times greater than those obtainable from sulphuric acid. The strength of acid required attention when dealing with heavy discharges. Recently he had used acid having a maximum density 1·252, so that its specific resistance diminished as the cell discharged. In this way, and by the aid of copper supports for the spongy lead, he obtained a comparatively steady discharge of two amperes per pound gross weight of cell for two hours. With ordinary lead grids this would have been impossible.

Prof. Perry asked the distinguished chemists present if the double sulphate really exists, and

Prof. Ayrton enquired whether there were any simple tests by which such sulphates, if formed, could be detected.

Dr. Gladstone said Mr. Hibbert and himself had concluded that there was no evidence of double sulphate being formed in the action of secondary cells. He believed the general idea as to the influence of sodium sulphate, was that lead sulphate was more soluble in the mixture than in simple acid; this, however, was not confirmed by experiments.

Mr. Crookes (the new president) said sulphuric acid had a great tendency to form double salts, and thought it very probable that such salts would be formed in the case under discussion. Some results published by Dr. Gore also point to the same conclusion.

Prof. S. P. Thompson was interested to learn that, like any other battery, the greatest action occurs at the upper parts of the plates. This might perhaps have been expected, because of its being the path of least resistance, but as the variation of the resistance of sulphuric acid with density is peculiar, and as the denser acid falls to the bottom, the action might have been modified thereby. The details relating to the formation of plates given in the second paper were, he thought, not new, and were practically what anyone having a knowledge of the properties of the substances used, and the reactions which it was desired to bring about, would have arrived at theoretically. For example, to oxidise the positives, one would aim at producing the most powerful oxidiser in the shape of ozone, the formation of which is facilitated by strong acid, large current density, and low temperature. On the other hand, to reduce the litharge on the negatives it was known that a large current density mainly produces gas, and that reduction is best effected by small current density at a fairly high temperature. Bearing in mind these opposite conditions one readily realises that the plates should be formed separately and that the negatives will require a much longer time. Several years ago he tried cells with electrolytes other than sulphuric acid, and found that phosphoric acid was the only one which gave fairly good results. Speaking of parted cells, Dr. Thompson enquired whether the authors had noticed that the oxidation of the positive paste begins near the grid and gradually spreads through the mass of the plugs, and whether a useless nucleus remained unacted on n the centre of each.

Replying to Prof. Thompson, **Mr. E. A. Hall** said he had made experiments on the capacity of cells with plates of different thickness, and found it independent of the thickness. This, he thought, tended to confirm Prof. Thompson's view as regard a useless nucleus. On the question of acid density, he found that the capacity of a cell was increased 15 per cent. by using acid of specific gravity 1·15, instead of 1·20.

Mr. Preece rose to correct an error made by Mr. Drake at the last meeting, in stating that the density of acid in the P. and O. battery had been 1·40. Mr. Hall informed him (the speaker) that it had never exceeded 1·22.

Mr. T. Fraser took exception to the remarks made by Mr. E. W. Smith in his reply to the discussion at Edinburgh, with reference to the formulæ he (Mr. Frazer) had given for the resistance of cells for different currents, and for the fall of E.M.F. when the charging circuit is interrupted. In spite of what Mr. Smith said, he maintained that his own statements were correct.

Prof. Ayrton, in replying, said the authors greatly appreciated the cordial reception given to the papers by practical engineers, for one of the aims of the Central Institution was to train students to do work and carry out investigations, the results of which would be of commercial value. Referring to Dr. Gladstone's criticism about the ammonium acetate method, he said that Mr. Robertson had used this method, but somehow or other the paragraph describing it had not been printed in the first proof. Speaking of measuring the resistances of cells, he pointed out that unless the curve connecting time and E.M.F. was discontinuous at the instant of breaking circuit, the method used should give correct results. So far as he knew there was no evidence of any such discontinuity. Mr. Crompton had said the resistance was practically independent of the distance of the plates apart, and that the sulphating of the negatives during rest depended greatly on light. Taking the case of resistance first, they had made experiments on a small two-plate cell, and found that when the ordinary method of testing was employed Mr. Crompton's statement seemed nearly correct, but on using the more sensitive method illustrated in Figs. 10 and 11 of

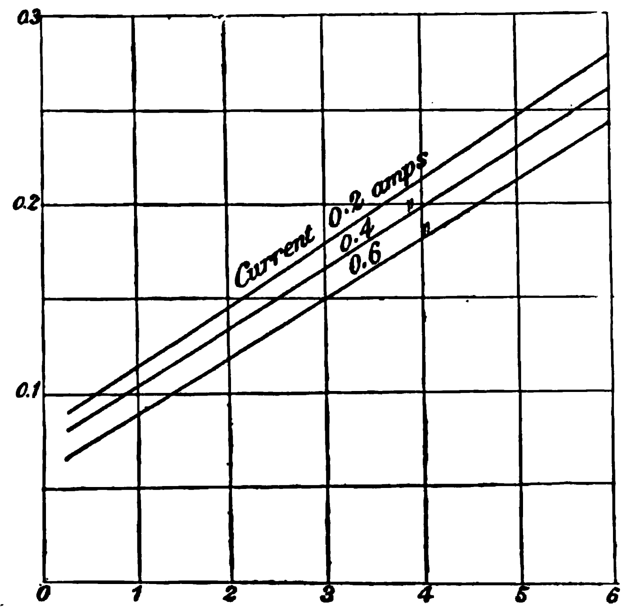


Diagram A.

the Edinburgh paper, this was not the case. Diagram A represents the results of these experiments. To investigate the effects of light, darkness, and sulphate of soda on the liberation of gas from idle negatives, they had experimented on three similar E.P.S. cells. The fully-charged negatives, designated by A, B, and C respectively, were put in three different vessels of acid, one of which contained 0·8 per cent. of sodium sulphate, and the gases collected. A powerful arc light illuminated one set of plates, whilst the others were kept dark. Plate A, when illuminated, gave off gas very rapidly, whilst B and C, in the dark, produced very small quantities, which were about equal. On interchanging the plates, however, it was found that neither light or sodium sulphate had any marked effect on the rate at which gas was given off, for whether A was illuminated or kept dark, or put in ordinary acid or in the sodium sulphate solution, gas was liberated rapidly at about the same rate, whilst B and C were equally inactive under all conditions. They therefore conclude that the rate at which gas is liberated depends on some peculiarity of the plates themselves. Some speakers, he said, had remarked that many of the facts brought forward in the papers were previously known. To this he replied that none of the facts given as new were known to the authors before they discovered them experimentally. Manufacturers might have been aware of them, but if so, they had kept them secret and never published them. For example, Dr. Gladstone, one of the highest authorities on secondary cells, was not aware of the differences in the hardness of the plugs at different parts of the plates until the appearance of their paper. Another case in point was the fact that Dr. Thompson said there was nothing new in the methods of forming the plates, whereas Mr. King apparently did not know of them. Mr. Swinburne had also called their attention to a prediction of the cooling of cells during discharge made in 1887, but at that time he admitted that he had not observed it. Speaking of the efficiency of cells, he said some people think the very perfect testing apparatus gave the cells their high efficiency; this, of course, was not true, for their figures merely express the results obtained when cells are used in a proper manner. Referring to a criticism on the Edinburgh paper which appeared in one of the leading technical papers of July 25, he said the writer had only partly understood the early part of the paper, for they (the authors) had there explained that one of the objects of the investigation was to see what error could be made by neglecting the previous history and the resuscitating power of cells. The same writer had also stated that the results of laboratory tests were not applicable to ordinary conditions. Here, again, he had fallen into error, for a secondary cell is a thing complete in itself; and if two or three selected at random give good results under proper treatment, so any number if similarly treated will show equal efficiency.

THE

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 Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

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We may occasionally follow the lead of our American Contemporaries, especially when they point out a serviceable way. They are not backward in asking their friends to do all they can for the welfare of the paper. We ask our friends to remember us. No Paper that we know ever refuses Subscribers or Advertisers. Nor do we; in fact, we invite them, believing that they will get full value for their money.

Specimen copies of the paper will be sent on request.

PROVISIONAL ORDERS AND LOCAL AUTHORITIES.

The public meeting at the Town Hall and the discussion at the Town Council meeting of Gravesend show at once the weakness and the strength of the more progressive councillors in relation to electric lighting matters. For many a weary month the question of obtaining a provisional order has been before the Council. Up to a point a fair amount of harmony prevailed, but at the meeting when it became necessary to affix the seal of the Council, and pay certain moneys to the Board of Trade, several of the supporters of electric lighting being absent, a vote was taken which stopped further progress, the opposition voting against the proposal being greater than its supporters by eleven to eight. Upon this adverse vote, a public meeting of the ratepayers was called, and this meeting supported the obtaining a provisional order. Subsequently, an attempt was made to rescind the vote of the Council, but this was vetoed by eleven to nine, so, for the moment, the Local Authority will not proceed with an order. We are not so much interested in the position of affairs at Gravesend as in the arguments brought forward to support and to oppose action. Taking the latter first, we have the old cry: "A visit to the Patent Office would show anyone that constant alterations and improvements in electric light were taking place—hence, Gravesend should wait until the system became more perfected and more within the range of the general purse." A more inane argument it is difficult to conceive—in fact, this argument seems to be the apotheosis of ignorance. Is there one single industry so perfect, that improvements are not being constantly made and patents taken out? Are iron manufacturers to stop business because improvements are being made in iron manufacture? Are cotton, woollen, and silk mills to stop spinning because patents are being taken out to improve the machinery? If we are to wait for the last improvement and stand "as you were" till perfection is reached, progress is impossible till humanity becomes infinitely wise. There are no words of condemnation too strong against the ignoramuses who use such arguments. Their plea is absurd. Did we wait for the modern locomotive before constructing railroads, or the modern triple expansion engine before constructing steamships? No! Men then took, as sensible men now take, whatever is a step onward, and do not wait for the steps to become a precipice. We now come to the supporters of progress, and in this instance they learned their lessons badly. The principal speaker stated that the Swan and Edison Electric Company were prepared "to build an engine-house and offices, erect engines and motors, construct and fix overhead wires, and provide 1,000 lamps for £2,100." The hearers evidently understood the speaker to mean that the total cost out

and out of an installation of 1,000 lamps would only be £2,100, an amount which is to the technical reader so utterly inadequate that no hesitation can arise in dismissing it as a mistake. How and where the mistake arises are questions the speeches do not provide us with an answer.

At Gravesend, then, we see supporters badly informed, and making statements that it will be difficult to counteract. The future promoter will be met with these statements, and if in 1891 he says the price is impossible, he will be told it was possible in 1890, and ought to be possible in 1891.

It seems to us an absolute necessity that the Edison-Swan Company at once give the statement a direct and unmistakable denial, pointing out, if possible, where the error has arisen, but if this is impossible they must rest satisfied with a simple contradiction. The ordinary mind is filled with mistaken notions relating to electrical matters. Technical papers can do little to eradicate the evil, because they are few among the many. Any absurd statement about electrical matters seems to command a space in the local and general papers, and once the error is started on its way there is no possibility of overtaking it.

MR. CHAMBERLAIN v. MR. COURTENAY.

The letters which have appeared in the *Times*, and which we have reprinted in our columns, on the subject of "voltage," are most important. Some time since, when asked to advise a consulting electrical engineer (who was preparing a report and specification for lighting of a large town) as to the percentage to be allowed on either side of the normal 100 volts of pressure, we pointed out that, for reasons well known to electrical engineers, the fluctuation should be as small as possible. It is agreed on all sides that the amount of light is due to the energy expended after a certain temperature is reached by the incandescent material. A very large percentage of the total voltage is used in bringing the filament from the ordinary surrounding temperature to that of red heat; the remaining voltage used raises it from red heat to white heat. If, now, the temperature at which a lamp will give the normal candle-power requires a pressure of 100 volts, it is very sure that a diminution of pressure of four volts will cause a much larger diminution of light than the ratio of four to 100—that is, the candle-power will be diminished much more than 1-25. Were this not the case, the light, by a drop of voltage from 100 to 96 volts, would be reduced to 15·36 candles, instead of the normal 16. Photometricians—even allowing that their art is still defective—will be able to prove that a drop from 100 volts to 96 volts in a lamp constructed for 100 volts will diminish the candle-power more than ·64 of a candle. The legal question may allow a drop of four volts, but if this practice is generally followed good-bye to success. A red-hot filament is not what users want or expect, and it is not what they should have. The remedy is simple: if 96 volts is to be the recognised limit use 96-volt lamps and not 100-volt lamps.

STREET LIGHTING.

The report given in our last issue of Mr. I. A. Timmis to the Dover Corporation raises the important question of arc *versus* incandescent lamps for lighting streets and large open spaces. Opinions seemed to be so generally favourable to arc lighting, both on account of cost and intensity of light, that a different opinion at this stage is noteworthy. It is a singular fact, but one which claims attention, that whenever incandescents have been used for street lighting the troubles have been more and the disputes more violent than when arc lighting has been used. Further, there have been few changes from arc to incandescent, but many from incandescent to arc. It seems, then, that the suggestion to use incandescents is somewhat unorthodox, and, if precedents are of any use as guides, likely to lead to failure. From our knowledge of Dover and Dover Harbour we incline to the opinion that arc lamps are pre-eminently necessary, that too much light can hardly be given, and that incandescents will lead to an endless number of difficulties. The introduction of electric light is supposed to mean the introduction of more light, but incandescents of 16 c.p. nominal and here and there a 200 c.p. nominal, most at double the distance of existing gas lamps, looks like retrogression rather than progression. Perhaps a better scheme of distribution may give more light, but, upon the face of it, this seems almost impossible.

ELECTRICITY AS A MOTIVE POWER.

In a prize essay on "The Best Means of Promoting the Industries of Wales," by Mr. J. E. Thomas, mention is made of the use of electricity as a motive power. We may not agree with the whole of Mr. Thomas's conclusions, but he gives valuable information as regards the possibility of applying the waste water power near Wrexham to the purposes of electricity. The drainage area is principally the Minera and Bwlchgwyn hills. There is a fair amount of water and plenty of head, and this can be utilised without any interference with mill or water rights. The author of the essay suggests that a powerful water-wheel placed in the Nant dingle would supply at all times a sufficient power to enable the town of Wrexham to be lighted electrically, also for the various industrial operations established in the town. The neighbourhood of the Nant valley just below the Wern is about 500ft. above sea level, while the site of the Wrexham Town Hall is about 270ft. above

sea level, so that on either side power is running to waste. As the author states, living upon a coalfield renders coal comparatively cheap, but in this case, when coal exhaustion takes place, there will be a seeking for some other source of power. There are, however, many places not situated on or near a coalfield where power may be similarly running to waste, and it behoves the inhabitants of such places to consider the advantages electricity offers in distributing power. Towns once prosperous have decayed, hamlets once rural are centres of a teeming population. Natural conditions have acted in working these changes, and no doubt the possession of waste water power will enable many a pretty village to become the centre of industrial operations hitherto undreamt of. Some of our pushing supply firms might do worse than examine the natural features of the country and endeavour to promote the utilisation of waste water power.

CORRESPONDENCE.

WINTER LIGHTNING.

To the Editor of the Electrical Engineer.

Sir,—I see in the *Electrical Engineer* of December 19 that the flash seen at Sutton on Sunday evening, the 14th inst., was "caused by the fall of an exceedingly bright meteor."

Would this account for the fact that in Gloucester I saw two distinct flashes with an interval between them of at least six minutes? These flashes were intensely white, and of scarcely a moment's duration; if caused by a meteor fall would they not have lasted a few seconds?—Yours, etc., G. E. Venning Thomas.

Gloucester, Dec. 20, 1890.

[Note.—We are always glad to insert letters from correspondents, but our pleasure is not without alloy when they write on both sides of the paper.—Ed. *E. E.*]

ELECTRIC LIGHTING IN LONDON.

The following additional correspondence on this subject has appeared in the *Times*.

Sir,—I have seen with some astonishment the chairman's letter in your issue of to-day's date. He suppresses paragraphs in my question to the Board of Trade which affect the company's good faith. These are:

"Whether the Board of Trade have allowed this company a margin of four volts either way, and that the latter have taken advantage of this concession to give an average during lighting hours of 97 volts instead of the 100 to which consumers are entitled. Whether complaints of this default were made to the Board 12 months ago, and assurances then made by the company of immediate amendment."

And it was on these that followed the paragraph he quotes—viz.: "Whether he will take steps to compel this company to keep faith with the public, or to forfeit their concession." The chairman says: 1. "The Chelsea Company has not failed to keep faith with the public." This is quite incorrect. The company undertake to give their consumers 100 volts, and they have egregiously failed to do so; the average during lighting hours being from 96 to 98, and going down during the recent fog to below 88; while on Saturday morning they broke down entirely, and for eight hours there was no current available whatever. To-day also from an early hour all supply has been cut off.

2. Mr. Courtenay says: "The pressure for this year has averaged over 100 volts, ... but the regulations . . . . allow a variation of 4 per cent. . . . . which of necessity takes place, and which is imperceptible to the consumer without the use of delicate instruments."

This is an evasion, "the same with intent to deceive." My complaint is as to deficiency during lighting hours. The chairman's average is obtained by including daylight and other non-lighting hours when the current is immaterial. The company have never given the average of 100 volts during lighting hours, and it is wilfully misleading to take the average based on the 24 hours during two-thirds or more of which time no consumption is taking place. The delicate instrument for testing I have had to purchase, and their engineers, after repeatedly checking it, have only confirmed its accuracy.

The variation laid down by the Board of Trade, as the chairman knows full well, is for the purpose of meeting exceptional strains, but is abused by the Chelsea Company, who persistently take advantage of it, and in spite of complaints ranging over more than 12 months only vary downwards and never during lighting hours upwards, and in this way impose upon their consumers a lower standard, and, therefore, a lower illuminating power, than what was promised.

3. Mr. Courtenay says: "There has never been a failure of light, and hardly any complaints (except from Mr. R. Chamberlain) have been received from customers, and those few were remedied at once."

This, again, is at variance with the facts. Apart from the absence of all current to-day and on Saturday, the default in supplying the full 100 volts during lighting hours causes, as everyone knows, a great failure of illuminating power, while during the recent foggy weather the company have been so utterly unable to cope with their responsibilities as to drop down the pressure to below 90, and their consumers' houses have been almost in darkness.

I am afraid the statement as to their having hardly any complaints is not more accurate than his others, notably as to a member of Parliament being a man of leisure. I have heard of many complaints, and in one instance at least besides my own a complaint has not been remedied.

Mr. Courtenay endeavours to raise a false issue by suggesting that my not unreasonable complaints arise from some interest of mine in the Chamberlain and Hookham meter. If it were true that I were interested in this meter, it would not make the default of the company or their breach of faith to their customers one whit worse or better than it is. As it happens, however, the suggestion is quite uncalled for. I have not and never have had the slightest interest in the success of the meter referred to.

In conclusion, I challenge Mr. Courtenay to affirm that his company have given or are giving an honest 100 volts —*i.e.*, an average 100 during lighting hours—or to deny that there is a great loss of illuminating power from default to do so.

Further, I challenge him to inform the public, through you, when, if ever, his company will give this supply.

It is only because I cannot get any redress or any definite date when redress will be afforded that I have taken steps to compel an honourable fulfilment of obligations into which the company have entered.

Surely they are very shortsighted; they have a very good area, and it would be better for them to put their plant and appliances in proper order so as to give in future a full and constant supply rather than to have their concession modified or cancelled, or another company brought into the district.

Whenever the company will honourably perform their obligations and supply me with a constant and honest average of 100 volts during lighting hours, I, at all events, will cease from troubling.

Meanwhile, I write by candle light, and with my house in darkness, and wonder what Mr. Courtenay would call a default.—I am, Sir, yours obediently,

Richard Chamberlain

39, Cadogan square, S.W., Dec. 15.

Sir,—In reply to Mr. Richard Chamberlain's letter in

the *Times* of the 19th inst., I have to state that my company having supplied light within their statutory powers have not, and never had, any issue on that head to discuss with Mr. R. Chamberlain, and I decline to be drawn away from the object of my letter on the 10th inst., which was to protect my company from Mr. R. Chamberlain's attack in the House of Commons, an attack which, if not explained, was liable to damage the interest of those I represent.

Mr. R. Chamberlain may have asked other questions of the President of the Board of Trade, but all I had to deal with were those which appeared in your parliamentary report of the proceedings in the House of Commons of the 9th inst.—namely :

"Mr. R. Chamberlain asked the President of the Board of Trade whether his attention had been called to the long-continued default of the Chelsea Electric Supply Company to furnish the statutory current of 100 volts, and to the serious loss of illuminating power sustained by consumers in consequence, and whether he would take steps to compel this company to keep faith with the public or forfeit their concession."

The answer of Sir M. Hicks-Beach to the question, and Mr. Chamberlain's remarks, as reported, show that he completely misunderstood the company's obligations. The report concludes as follows : "Mr. R. Chamberlain,—I understand from the right hon. gentleman that we have no remedy unless they get below 96, the 4 per cent. referred to in the answer just given.

"Sir M. Hicks-Beach : Yes, sir, that is so.

The variation permitted by the Board of Trade is allowed to enable the company to cope with the increase of demand during the hours of maximum lighting, without compelling the company to incur excessive expenditure on the conducting mains.

The recent continuous fogs have been a severe strain on the company, and in consequence the company was obliged to issue a notice on the 12th inst. informing its customers "that, owing to the continued drain on the reserves of electricity in the accumulators at the sources of supply caused by continuous foggy weather, the company, in the mutual interest of itself and of the efficiency of the service to its customers, may find itself obliged to cut off the current from its system of mains during certain hours between midnight and four o'clock in the afternoon ; the issue of this notice is to prepare for such possible contingency."

The dates show this occurred after Mr. Chamberlain's attack. In December, 1889, the company supplied 8,730 lights, and they are now supplying about 20,000, which, I think, conclusively shows that our customers have been fairly satisfied.

I believe in such weather as we have lately experienced even the old-established gas companies frequently have to work with diminished pressure.

My company have done their best to combat with the very trying and long-continued fogs, and we have to thank our customers for the consideration they have shown.—I am, Sir, your obedient servant,

J. Irving Courtenay, Chairman,
Chelsea Electricity Supply Company, Limited.

Chelsea, Dec. 20.

ACCUMULATOR REGULATOR.

In installations in which accumulators are used, it is found when charging them that the E.M.F. of the dynamo has to be so many volts higher than that of the battery that the lamps cannot be used without endangering their life. In such cases an arrangement should be used enabling the main supplying the lamps to be shifted down the battery four or five cells to a point at which the difference of potential is suitable for the voltage of the lamps. A new patent regulator for this purpose is here illustrated, made by Messrs. Dorman and Smith, of Manchester and London. The lead from the dynamo is attached to one of the swivelling contact pieces, and the lead to the lamps to the other, and a wire from each of the six top cells is connected with the six coupling strips. The movement of the swivelling arms from one jaw to another is remarkably sudden, and independent of the speed at which the handle is moved, and the distance between the jaws is such that it is impossible for the cells to be short-circuited.

When the cells are merely used to steady the current from the dynamo the charge and discharge takes place at the same point, whereas when the dynamo is stopped and the cells used as the main source of supply, the discharge is usually taken from the top cell of the battery. All these conditions are easily met with the arrangement of switches shown.

ELECTRICITY FOR NURSES.

The application of electricity to medical practice during the past few years has begun to be taken up in a *dilettante* fashion by doctors, though too often with a kind of empirical and see-what-the-result-may-be manner—a method which, it is whispered, is not altogether unknown in the profession with other matters more usually believed to be thoroughly understood. In older days it was the fond hobby of enterprising medical students who achieved certain wonders in cure, but who had to be warned that the award of their diplomas was dependent upon the abandonment of all such heterodox views and practice. Later, electricity in medical practice has become acknowledged, and has developed in two directions. One of these is the application of well-known electrical effects for surgical and other purposes—the electric light, with minute surgical lamps for the lighting of the cavities of the human body ; the heating effects for galvano-cautery ; and the electrolysis of tumours and other vicious products of the body, a direction itself in which much remains to be done for the benefit of suffering humanity. The other direction is one which is, it may be said, both more delicate and more often invoked, as well as more empirical, and more in need of scientific direction than the first, as it is given into the hands of the ordinary practitioner, the hospital doctor, and the nurse. This is the application of electric currents externally to the body for the purposes of excitation, soothing, or renewal of failing muscular or nerve action—in a word, what is usually meant by battery electrification. The use of electricity is now so common that nearly all medical schools and hospitals have their batteries and apparatus. Yet it is often the case that the medical men who prescribe and the nurses who carry out the instructions know little or nothing of the ordinary phenomena of electricity, and are far from being able to watch, predict, or properly direct its use upon the human body. It is, therefore, a great benefit to the medical profession when a trained electrician can do, as Mr. Newman Lawrence, M.I.E.E., is persistently doing—that is, devote his training and his life's energy to the study and the scientific organisation of the interesting and important problems that arise from the use of electricity as a therapeutic agent. Mr. Lawrence, as electrical engineers know from the papers

already given before the Institution, has associated himself with Dr. Harries, and together they have undertaken investigations which bid fair to inaugurate a considerable revolution in certain branches of medical practice.

On Thursday week, December 11th, Mr. Newman Lawrence gave a lecture to nurses on "Medical Applications of Electricity" embodying some of his views, at the new premises of the Institute of Medical Electricity, 35, Fitzroy-square, W., the chair being taken by Miss C. J. Ward (hon. sec., British Nursing Association). The lecture was illustrated by practical demonstrations on living subjects—patients at the institute—the object of the lecture being principally to inculcate a suitable knowledge of the effects of electrical currents and the necessity for the exact measurement of the "doses."

Mr. Lawrence referred to his own position as not that of a medical man, but an electrical engineer. Electricity, he pointed out, was being largely used in medical practice, and its nature and effects should be almost as much studied by medical men as by telegraphists or electric light engineers. He explained how electricity in its varying manifestations was one and the same force, and mentioned that to prove to certain persons this truth, he had undertaken a series of experiments with a dynamo current taken from an electric light circuit and conclusively arrived at the result that the physiological effects were the same. The lecturer explained the differences between large current strength and high pressure. He went into the differences between continuous, alternating and intermittent currents, and showed the experiment of decomposition of water into its constituent gases. On application to the human skin it had been found that physical congestion takes place under both poles, with the effect of stimulation of nutrition. The acceleration of osmosis (the transfer of different liquids through a skin partition) by electricity was a most important property of the electric current, taken advantage of in the process termed by his colleague Dr. Harries as "cataphoric medication," in which drugs could be locally administered in the right quantities, instead of, as with the present practice, by swallowing large quantities of which small portions only found their way to the required part, and the rest might even do injury. The breaking up of bad growths or the discharge of deleterious matters in any organ could, conversely, be brought about by "catalysis."

Mr. Lawrence then dealt with the important point of "dosage"—the dose of current to be administered. Too often it was prescribed most loosely, as "apply 10, or 20 cells," or "as much as the patient could bear." A dose to be exact should be specified in the two factors of strength and time—so many milliamperes for so many seconds or minutes. The method of doing this was practically illustrated—a switchboard of his device made by Coxeter's, with Leclanché cells, and a milliampere-meter being used in administering current to a youth's forehead, neck, and back, in the simple manner devised by the lecturer to enable nurses to carry out doctors' prescriptions. The utter uselessness of the ordinary methods of depending on the number of cells or the patient's sensation was shown, and then manipulations with 1½, 5, 9, etc., milliamperes were carried out. A further experiment with a female patient for the face and arm were given to the nurses present, allusion being made to many successes achieved with cases of facial paralysis. A model of the administration of electric currents in baths was exhibited, the *desiderata* being always that the direction and strength of the current should be known and scientifically applied. Mr. Lawrence deplored the comparative ignorance of medical men, which was too often the cause of the bad application of the remedies by the nurses, and urged the greater study of electricity in the medicine schools. He insisted on the necessity for strict definition of words, and proposed the term "flowruption" for an intermittent direct current, as distinguished from an "alternating current"—a hideous hybrid, however, which it is to be hoped he will forego for the correct term. Mr. Lawrence was extremely lucid in his explanation, and skilful in his methods, and his work in the strict measurement of "dosage" will surely prove most valuable to medical men.

At the conclusion of the lecture (which evoked much praise from the chairwoman) Dr. Harries alluded to some points of recent progress in the stimulation of muscles and nerves, and of nutrition. The greatest discovery, one which evidently promises to become a most valuable adjunct to surgical practice, he described as local anæsthetisation by means of cataphoric transmission—the anæsthetic drug cocaine being transmitted by electrical agency to any local part in such a way and with such ease that surgical operations, such as red-hot cautery, have been performed three successive times upon a limb without the patients feeling it in the least. To avoid the risk inseparable from chloroform, or even ether, in minor operations, the application of electric science to that of anæsthetics, through the discoveries of Messrs. Lawrence and Harries, seems to promise progress of really startling importance. The use of electricity for the stimulation of nutrition of structure, electrolysis of tufts of hair, and other kindred cases, though extremely useful in themselves, seem very minor beside an application of this extended usefulness. The scientific study of electricity in medical practice has evidently large fields before it, and the gentlemen named are attacking the subject in a manner in which both medical and electrical men will recognise the true scientific spirit.

THE ELECTROMAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

LECTURE IV.

ELECTROMAGNETIC MECHANISM.

The task before me to-night comprises the following matters: First, to speak of that particular variety of the electromagnet in which the iron core, instead of being attached to the coils, is movable, and is attracted into them. Secondly, to speak of the modes of equalising the pull of electromagnets of various sorts over their range of action. Thirdly, to describe sundry mechanisms which depend on electromagnets. Lastly, to discuss the modes of prevention or diminution of the sparking which is so almost invariably found to accompany the break of circuit when one is using an electromagnet.

THE COIL AND PLUNGER.

First, then, let me deal with the apparatus wherein an iron core is attracted into a tubular coil or solenoid, an apparatus which, for the sake of brevity, I take the liberty of naming as the coil and

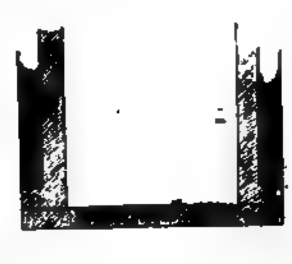

FIG. 57.—Hjörth's Electromagnetic Mechanism.

plunger. Now, from quite early times, from 1822, at any rate, it was known that a coil would attract a piece of iron into it, and that this action resembled somewhat the action of a piston going into a cylinder—resembled it, I mean to say, in possessing an extended range of action. The use of such a device as the coil and plunger was even patented in this country in 1846 under the name of "a new electromagnet." Electromagnetic engines or motors were made on this plan by Page, and afterwards by others,

* Cantor lectures, delivered before the Society of Arts.

Name of Town, Parish, or District.	Local Authority or Company Applying.
East London	Laing, Wharton and Down Construction Syndicate, Limited.
Hampstead	Stamford Hill, Tottenham, and Edmonton Electric Light and Power Supply Company, Limited.
Islington	Camberwell and Islington Electric Light and Power Supply, Limited.
North London	Brush Electrical Engineering Company, Limited.
North Westminster	Westminster Electric Supply Corporation, Limited.
Paddington	Paddington and Bayswater Electric Light and Power Supply, Limited.
St. Luke's, Chelsea, and St. George's, Hanover-square	New Cadogan and Belgrave Electric Supply Company, Limited.
Southwark	Brush Electrical Engineering Company, Limited.
Wandsworth District	Stamford Hill, Tottenham, and Edmonton Electric Light and Power Supply, Limited.
Woolwich	Woolwich District Electric Light Company, Limited.
Londonderry	Corporation.
Newcastle	Newcastle and District Electric Lighting Company, Limited.
Newport (Mon.)	Corporation.
Norwich	Norwich Electricity Company, Limited.
Paisley*	Corporation.
Poole	Brush Electrical Engineering Company, Limited.
Preston	National Electric Supply Company, Limited.
Scarborough	Corporation.
Southend	Local Board.
Southport*	Corporation.
South Shields	Corporation.
Stockport*	Corporation.
Sunderland	Corporation.
Surbiton	Improvement Commissioners.
Torquay	Local Board.
Toxteth Park	Liverpool Electric Supply Compan Limited.
Tunbridge Wells	Corporation.
Tynemouth	Corporation.
Weston-super-Mare	Improvement Commissioners.
Weybridge	Laing, Wharton, and Down Construction Syndicate, Limited.
Weymouth	Brush Electrical Engineering Company, Limited.
Whitby	Local Board.
Whitehaven	Town and Harbour Trustees.
Withington District	Manchester House-to-House Electricity Company, Limited.

Total number 70.

It will be seen on comparison with our list given on Dec. 5th, p. 513, that six applications have been dropped. These are Cork, Gravesend, Limerick, St. Martin's-in-the-Fields, Maidstone, and Windsor and Eton.

COMPANIES' MEETINGS.

THE GULCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY, LIMITED.

Directors: D. De Castro, Esq., H. Grëwing, Esq., R. Pryor, Esq
Secretary: T. C. Morgan, Esq.

REPORT.

The Directors have pleasure in presenting to the shareholders the balance-sheet for the 12 months ending June 30, 1890. It will be observed that the preference capital of the Company, which, on June 30, 1889, consisted of 12,277 preference shares, having £12,241. 1s. 4d. paid up, consisted on June 30, 1890, of 50,000 preference shares, having £30,797. 8s. paid up. It will also be seen that the £10 per cent. second debentures, which on June 30, 1889, amounted to £8,862. 10s., and which at the date of the last report had increased to £16,000, were on June 30, 1890, reduced to £400. This satisfactory alteration of the capital account is mainly due to the response made by a limited number of shareholders to the prospectus issued on January 1 last, inviting subscriptions for the then unissued preference shares. The central stations for the public lighting of Wellington, New Zealand, upon which on June 30, 1889, the Company had expended £9,598. 18s. 8d., were shortly afterwards completed. On June 30, 1890, this important installation stood as a debtor in the Company's books for £13,486. 13s. 3d., since which time the amount has not been increased. The Directors, in their last report, pointed out to the shareholders that the commercial success of this undertaking would depend entirely upon the provision of further capital for private lighting. They concluded, however, after careful consideration, not to lock up so large a portion of the newly-subscribed capital as would be necessary to enable the Company exclusively to provide for this private lighting. A well-supported syndicate has accordingly been formed, which will not only provide for the private supply of the town but will ultimately take over this Company's business in New Zealand, together with the benefit of the contract for the public lighting entered into between this Company and the Mayor and Corporation of Wellington. The particulars of the contract between the New Zealand Electrical Syndicate and this Company, and of other contracts undertaken and carried out during the past year, will be supplied at the general meeting, when a detailed profit and loss account will also be submitted to the shareholders. In the autumn of last year this Company contributed towards the registration of the South-Western District and Thames Valley Electricity Supply Company, Limited, from which the Directors have reason to anticipate good results. The gross manufacturing profits for the year ending June 30, 1890, amounted to £3,097. 2s. 4d., which, compared with the manufacturing loss of £1,417. 6s. 6d. in the preceding year, must be regarded with satisfaction. The heavy interest payable on the second mortgage debentures (nearly all of which, however, have now been paid off) has alone prevented the declaration of a dividend. Since the last general meeting Mr. Binswanger has resigned his seat at the Board. The Directors, under the powers conferred on them by the articles of association, recently elected Mr. C. S. B. Hilton, a large shareholder, to assist in the direction of the Company. Mr. De Castro and Mr. Hilton retire from the Board, but, being eligible, offer themselves for re-election. Mr. Russell Day, the auditor appointed at the last general meeting, also retires, but offers himself for re-election.

BALANCE-SHEET.

Dr.	£	s.	d.	£	s.	d.
Capital, authorised	70,000	0	0			
Issued 20,000 deferred shares of £1 each, fully paid	20,000	0	0			
12,277 preference shares of £1 each, 20s. called up	12,277	0	0			
37,723 preference shares of £1 each, 7s. 6d. called up	14,146	2	6			
70,000	26,423	2	6			
Less unpaid	2,942	5	4			
	23,480	17	2			
Add calls paid in advance	7,316	10	10			
				30,797	8	0
£6 per cent. first mortgage debentures				8,000	0	0
£10 per cent. second mortgage debentures	10,000	0	0			
Less paid off	9,600	0	0			
				400	0	0
Bills payable				393	16	7
Creditors as under:						
Trade debts	1,561	12	1			
Commissions	1,500	0	0			
Interest on debentures	189	7	10			
Rent, rates, and taxes	56	19	3			
Law costs	190	8	4			
Salaries, etc.	132	5	1			
Directors' fees	236	15	10			
				3,867	8	5
National Provincial Bank of England, Limited				2,493	7	3
				£45,952	0	3
Surplus at 30th June, 1889	405	13	10			
Balance from profit and loss account	201	17	7			
				203	16	3
				£46,155	16	6

Cr.	£	s.	d.	£	s.	d.
Preliminary expenses, balance from June, 1889	800	0	0			
Add broker's commission, etc.	1,600	0	0			
	2,400	0	0			
Less written off	400	0	0			
				2,000	0	0
Plant (as valued)				7,028	18	6
Stock in England (as valued)				17,776	1	6
Stock in New Zealand (at cost)				1,048	6	3
Installation at Wellington, New Zealand (at cost)				13,486	13	3
Trade debtors				4,680	17	4
Bills receivable				69	3	9
Cash in hand				21	15	11
				£46,155	16	6

The third ordinary general meeting of this Company was held on Thursday, the 18th inst., at Winchester House, Old Broad-street, Mr. De Castro in the chair.

The **Secretary** (Mr. T. C. Morgan) having read the notice convening the meeting, and the minutes of the last meeting having been read and confirmed,

The **Chairman** said: Gentlemen,—Before we proceed to the business proper, I think it right to say that last year it was decided to hold our meeting as a private one, and a little unpleasantness arose between myself and some of the representatives of the Press

afterwards as to whether it was or was not private. We have no possible objection to treating this as a public meeting, and therefore if the shareholders wish it we can have no objection to the Press being admitted. My own view is that a Company like ourselves is not of vast interest to anybody but the shareholders, and therefore my own view is that we should keep the meeting to ourselves. However, I am entirely in your hands, and I only mentioned this in order that if the shareholders like to treat it as a private meeting, no member of the Press will have an excuse for saying it was not so. Will someone express the views of the meeting? I may mention that we are not quoted on the Stock Exchange.

Mr. Harton thought it would be going backwards to call this a private company. He hoped to have a Stock Exchange quotation, and therefore he thought the meeting should be open and public.

This was seconded by another shareholder, and carried unanimously.

The **Chairman** then said: Gentlemen,—I think you have all received copies of the report and balance-sheet, which will require very little comment from me. (We give the report, etc., herewith.) I will just run through the report, and make a few observations as I go along, and any criticisms by yourselves are invited. The year since the 30th June has been a very important one to this Company. On the 30th June, 1889, we had a very small preference capital—comparatively—of £50,000 nominal. We had £12,277 paid up or subscribed, and we had at that time £8,000 mortgage debentures. We had no less than £10,000 second mortgage debentures, and we had another £6,000 second mortgage debentures, which we had been obliged to raise in order to meet the extreme difficulty the Company was placed in by a contract entered into in New Zealand. This year I am happy to say things are in an entirely different position. We found that however prosperous the Company might be or whatever its prospects, it was hopeless to expect that with so small a capital, burdened with such heavy mortgages, £16,000 of them bearing such a very heavy rate of interest, which we were obliged to pay before we could possibly declare dividends. I therefore went round and represented the case to my friends, and we agreed amongst ourselves, and the Board agreed, that the alternative was to propose an issue of the balance of our capital, and to pay off these heavy debentures which were absorbing all our profits. Accordingly in the beginning of last year we issued the balance of the preference capital, amounting to £37,723, in £1 shares. That has been subscribed very largely by those who hold the 10 per cent. debentures, exchanging those debentures for preference shares (with the addition to our list of a number of very excellent new shareholders), and partly by a certain amount which was underwritten. The capital, therefore, now stands, as your report tells you, at £50,000 preference shares, of which £30,797 were on the 30th June paid up, and I may tell you that at the present moment we have not only discharged all our 10 per cent. debentures (with the exception of £200, held by a gentleman who declines to be discharged), but we have a handsome capital of £30,000 subscribed, and £13,000 uncalled. This is a position that neither the old nor the new company have ever attained before.

The business to which I referred a few moments ago as having plunged us into difficulty, was the undertaking, through a mistake of our late manager, of a contract in New Zealand, which cost at least six times what he thought it would. What he estimated to cost £2,500 has cost this Company now £13,500. This is, even in our altered circumstances, a very large share of our capital to have locked up in what is not properly the business of this Company. We are a manufacturing electrical engineering and not a supply company, and, of course, the capital invested in a supply company must be very much larger than a company of this kind can afford. Moreover, the capital (£13,500) would not produce an income proportionate to that outlay; and to make it pay it would be, and will be, necessary to lay out at least another £9,000 or £10,000 to produce a substantial interest upon the £25,000 or £26,000 which will then be invested there. Under these circumstances it became a matter for the serious consideration of the Board as to whether we should employ our uncalled capital (this £13,000 or £14,000); whether we should lock that up, and again leave ourselves with very little free money. We decided in the early part of the year that if we could possibly avoid doing so to any extent whatever, we would, and at the suggestion of my colleagues I have been occupied, I think I may say the greater part of this year, certainly since the beginning of January, in forming a syndicate who will provide, as I think it is stated in your report, for the private supply of the town of Wellington; and not only that but will ultimately take over this Company's business in New Zealand, together with the benefits of the contract for public lighting of the town. That syndicate has at last been formed, and £10,000 has been subscribed, of which this Company will at the most have to risk £2,000 or £2,500 of our spare capital. I don't think there will be any necessity for finding a shilling towards it, because my impression is that with the powerful names we have upon the syndicate, and the assistance that is being given to me by firms that have helped us, there is very little doubt the shares for which the Gulcher Company will take responsibility will be easily taken in the colony or elsewhere. I hope, therefore, that when we meet again—if we are to meet you again?—next year we shall be able to report to you not only the completion of the contract, but the completion of the work which will have been done by the expenditure of this money, and the receipt of a revenue which will in itself be sufficient to declare a substantial dividend upon the whole capital of this Company. The price at which the New Zealand installation stands in our books at the 30th June is £13,486. 13s. 3d. That figure has not been substantially—in fact, not at all—added to from that date to this. The price which we shall obtain from the syndicate is £16,000 in fully paid-up shares. We shall, as you will therefore see, instead of having a large sum locked up in a perfectly untransferable form, have shares which will be transferable—shares in a company that will be about twice as strong as the Gulcher Company is out there at present. And we shall be deriving the benefit of that further expenditure of capital, which at the beginning of this meeting was indicated to you as necessary, on the part of others who believe in the prospects of the syndicate, without material expense to ourselves. There is another phase of this contract which I consider of great advantage. We are a manufacturing company. This syndicate—which will probably grow into a very much larger concern—will be a supply company, and I think there can be no doubt that if the goods we have sold in New Zealand continue to hold the position which they do now, this syndicate will become a very valuable customer to this Company, and that both directly and indirectly we shall be gaining by this transaction.

Another matter has been mentioned in the report, and that is that in the autumn of this year the Company contributed towards the registration of the South-Western District and Thames Valley Electricity Supply Company. We thought it well, having in view the tendency of business to run into central supply rather than into independent installations, that we should have an interest at any rate in some districts. While London was being portioned out amongst the great companies, we thought that if we could see our way, without material expenditure, to get a company registered, it would secure or tend to secure the preference, if not the monopoly, of a district. That it would be wise and to the interest of the Company to secure that at an expenditure of about £100. We have a share in a company which has been registered, and I have received promises of support from would-be customers in the immediate neighbourhood which this company comprehends. The company is intended to meet the demands of what I know to be a very growing district, the south-western district of the metropolis, including such towns as Kingston, Surbiton, Richmond, Putney, Barnes, etc. These are rich residential districts which are all clamouring for the light, and in which, without going into details, I think we have a very excellent chance of doing a very excellent business.

Coming to figures, the gross manufacturing profits—I am grieved to say there is no net profit — for the year ending 30th June, 1890, amounted to £3,097. 2s. 4d. Never since the Company has been formed have we made a gross manufacturing profit of even one-third of that. Last year under the difficulties that I have mentioned we made a loss of £1,417, therefore you have traded this year to an advantage of £4,500. The heavy interest, as is mentioned in the accounts, payable on the second mortgage debentures, amounting to over £1,000, has been the real reason why we have not been able to declare a profit. Although we carry over £3,000 to the credit of the profit and loss account, we are obliged to debit that profit with interest. But for that we should have been able to declare a dividend of fully 3 per cent., and next year I think we may fairly anticipate we shall do that and more.

Mr. Binswanger has retired from the Board. He came to us to represent some creditors having a very large stake in the concern. As soon as the bulk of the money was paid off upon those debentures he retired. I am quite sure my colleagues who worked with him will feel we are all very much indebted for the technical assistance and business acumen he brought to bear on this Company's affairs. And he left because he thought, amongst other reasons, that his and our businesses were so very much alike that it was difficult to decide whether they clashed or not. He has left us with every good feeling on our part. The Directors, under the powers conferred on them by their articles, have recently elected Mr. Hilton to the Board, and they hope you will confirm the election. In connection with the New Zealand syndicate, I think it is right to tell you that I am going to New Zealand next week to see if I cannot obtain powers for lighting not only Wellington but other towns in the colony. I am going, I hope, to put matters straight in Wellington—that is to say, I hope we shall be able by the assistance of the engineers out there, and by my taking powers to do in a week what it takes many months of correspondence to do, that I shall hasten the time when you will receive that dividend from our investment that I confidently anticipate. Under the circumstance we have cast about as to what is to become of the Board during my absence. We are, I believe, already the minimum, so far as numbers goes—the smaller the Board the more workable it is—at the same time with only two Directors here there is the contingency of not being able to make a quorum, which should not be neglected in my absence. We looked but a very short distance to find the proper man to be a director, at any rate in my absence, and I can only hope that he will be persuaded to remain afterwards, and we have temporarily elected Mr. Hilton. He is a large shareholder, and also without him and his firm we could not have got out of our difficulties with the New Zealand contract. He, his firm and his friends, have made out of what threatened to be our destruction that which I hope will be a most profitable third of our business. I suggested to his partner that if he would only induce him to come on the Board the Company would be more than well served. Another great advantage which I venture to think will be felt during my absence, is that Mr. Hilton lives within an hour's walk of our factory, and will be able to advise the Manager when necessary. I hope you will confirm his election as a Director.

Turning to the accounts, again, the first mortgage debentures remain. They are permanent debentures at 6 per cent., and very good investments. I think I told you that the whole of the £10,000 debentures had been paid off, with the exception of £200. It was £400 at the date of this balance-sheet, but since then £200

have been paid off. As to commissions, when we applied for £37,500 of new capital, the shareholders came forward with something between £17,000 and £18,000. It became a question whether we should get the balance underwritten by a broker, or whether we should stop half way. We decided to get the whole of the capital subscribed, and for that purpose we had to pay what I consider the very moderate sum of 7½ per cent. for underwriting half of it. The £1,500 is explained in that way. Off that we propose to write £400. The next item is that we appear on the face of this account to be a debtor to the National Provincial Bank for £2,493. That is the mere accident of one of our calls, amounting to £3,000, being payable on the 1st of July instead of the 30th June, and therefore in the ordinary course of banking, although there was no balance against us, the cheques in our books appear ante dated one day. The next day the whole of the money was in and there was a substantial balance of £1,000.

As to the future we have made arrangements to charge launches on the Thames from our works. Another item is that Mr. Fricker has designed two very excellent little dynamos for the purpose of supplying houses requiring 20, 30, 40, or 50 lights which are not within the districts of any supply company. He has also made a little motor which will work during the daytime from these dynamos, and do the work of small gas engines, or will drive sewing machines, etc. The dynamo we have called the "Hercules," and the motor the "Midget." We find there is going to be considerable demand for these. We have opened a showroom in Queen Victoria-street to bring our machines before the public. Another branch of work far more important than the above, and even more so than electrical property in New Zealand, is that we have made a contract with the only people that I know who have been able to weld steel and cast iron with any success. We shall have, so far as they can grant it, the monopoly of the supply of the machinery for this work. The experiments have been carried on now for nearly two years in the North of England by customers of ours. One customer has worked plant for over a year. The fact is getting rumoured about in the North, and we have had applications for other plants, and I anticipate great prosperity for this Company in this direction. Castings worth £15, £20, or £150 may be worthless because of a flaw 5in. long and 2in. deep. We are able by the process I am telling you of to weld this flaw, to insert new matter, so that when you chip the faulty casting you cannot find where the original flaw was, so entirely homogeneous is the metal when welded by this process. There are other things I should like to talk about, but I am afraid I am always too long on my legs. We have been lighting the Spanish and French Exhibitions for the last two years, and have at last succeeded in securing the German Exhibition for next year, and upon terms equally advantageous to ourselves. And I have also, I think, negotiated for the lighting of the Working Men's Exhibition—or rather a Labour Exhibition—which is to be held in another part of London. We shall therefore next year be sufficiently known by the lighting of the Crystal Palace and the German and this other exhibition, and I think our name must come forward more and more every day. The Naval Exhibition we could not afford to take, because it is being done gratuitously, and this is a business which doesn't suit the Gulcher. Now, I can invite any criticisims you may have to make.

Mr. Harton asked if the stock entered at £17,766 was taken at sale price or at manufacturing price?

The **Chairman**: At manufacturing price, and in many cases it is discounted.

Major Cotton prefaced his remarks by saying that the shareholders were very much indebted to their Chairman for his services. He, the speaker, had been a shareholder from the first, and spoke feelingly. He was sorry they were not getting a dividend. As to the underwriting of the capital, that was practically issuing the shares at a discount, and was a very awkward business. He thought counsel's opinion should be taken on the matter, as possibly the Directors might be made personally liable if anything happened. As to the New Zealand syndicate, the Company was finding £2,500 which possibly might not be required; but if the syndicate was a success he did not want other people to have the call of them in taking these shares in the New Zealand company. Moreover, it should be ascertained whether they were within their powers in putting £2,500 into that syndicate and the South-Western District Company. It appeared that they proposed, if the thing went through, to take £16,000 in fully-paid shares in the New Zealand company in place of their machinery, but they ought to get some cash. The machinery could be realised, but the £16,000 worth of shares might turn out to be unmarketable paper. He agreed with the Chairman that the Board should be kept small, but the object should also be to keep down expenses. But if they had a small Board and it drew the maximum fees, he didn't see the advantage to the shareholders. It was rather stiff to pay £250 a year to each of their Directors to meet once a month. No doubt they were entitled to their fees, but he hoped they might see their way to meeting the shareholders in the matter. As to the New Zealand estimate, of course blame attached to the people who made it, but still the Directors might have looked into it more.

Mr. Harton thought it would be better to have an opinion on the subject of the underwriting of the capital. He thought the New Zealand matter might be left to the Chairman. The proposition put forward seemed by far the best way out of the business.

The **Chairman** was much obliged to Major Cotton for his remarks. It was pleasant to hear them, when they had worked together for so long. As to the commission, he thought they took learned opinion. He was not quite sure whether it was counsel's opinion or not, but, at any rate, they took a lawyer's opinion before they agreed to give this commission, or whatever they might call it. But if they liked to allow the Board to spend the money in taking counsel's opinion they would do so, but it seemed to him to be no use.

Major Cotton, interposing, said it was a question of whether the shareholders were not liable as well as the Directors.

The **Chairman** (resuming) said: Very well; they would take counsel's opinion. As to the New Zealand matter, all the Board had taken a substantial sum in the new syndicate, as they believed in it. As Major Cotton had some doubt about the Company taking shares in it, they would be most delighted if he would come forward and take some himself and row in the same boat with them. They must not forget that the interests of the Company were doubly secured in this way, that the money which was going to be laid out would be largely applied in plant and machinery of their manufacture. He did take the responsibility for the error in the estimate for lighting. People ought to be perfect, but he was not. As they knew, all the engineering was left to their late engineer, and until then they had no reason to regret anything he did. However, once bit twice shy, and now they did look into contracts most carefully. He had to thank them for their criticisms, and would move the adoption of the report and balance-sheet.

This was seconded by **Mr. Grewing**, and carried unanimously.

Mr. Harton proposed the re-election of the retiring directors, Mr. De Castro and Mr. Hilton.

Major Cotton seconded, and this was carried unanimously.

A discussion then ensued, in which **Major Cotton** bore the principal part as to the election of further directors, Mr. Wallis and Major Cotton being suggested. However, this fell through, and the auditor, Mr. Russell Day, having been re-elected, the meeting terminated with a vote of thanks to the Chairman, proposed by **Major Cotton** and seconded by **Mr. Harton.**

NEW COMPANIES REGISTERED.

Electric Stores, Limited.—Registered by G. D. Freeman, 103A, Paul-street, Finsbury-square, with a capital of £15,000 in £1 shares. Object: to carry on as principals or agents the business of electrical stores. Registered without articles of association.

CITY NOTES.

West African Telegraph Company.—The Directors announce an interim dividend for the first half of the current year of 4s. per share, payable on the 22nd inst.

Business Notice.—We are informed that the style of Messrs. Ernest Scott and Co., electrical engineers, of Newcastle-on-Tyne, has been altered to Ernest Scott and Mountain, Limited.

Business Notice.—Messrs. Turvey and Gullette announce that they have opened an electrical instrument manufactory at White Horse Electrical Works, Cow Cross-street, Farringdon-road, E.C.

Telephone Company of Austria.—Coupon No. 12 of the 5 per cent. debentures of this Company will be paid, less income tax, by Messrs. Martin and Co., Lombard-street, E.C., on and after January 1.

Manitoba Electric and Gas Light Company.—Messrs. Robert A. M'Lean and Co. will, on and after January 1, pay the half-year's interest due on that date on the 6 per cent. first mortgage debentures of this Company.

Anglo-Portuguese Telephone Company.—Coupons No. 6 of the first mortgage and No. 1 of the second mortgage debentures of the Company will be paid, less income tax, by the Alliance Bank, Bartholomew-lane, on the 1st prox.

Electric Automatic Box Company.—It is notified that Mr. F. G. Painter, of the firm of Tride, Clarke, Painter, and Co., of Coleman-street, E.C., the official liquidator of the Electrical Automatic Delivery Box Company, Limited, will, with the sanction of Mr. Justice Kekewich, forthwith pay 20s. in the pound to all creditors who have proved their claims.

Eastern Telegraph Company.—This Company announce the payment, on January 15, of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum on the preference shares for the quarter ending December 31, and the usual interim dividend of 2s. 6d. per share on the ordinary shares, tax free, in respect of profits for the quarter ended September 30 last.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Anglo-American Brush	—	1¾
— Pref.	—	2
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	8
London Electric Supply	5	2
Swan United	3½	5
Crompton & Co., Pref.	—	5½
National Telephone	5	4½
Electric Construction	10	7½